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The Amphibians and Reptiles of the Hawaiian Islands

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(Text-figures 1-19)

Introduction

This paper presents an annotated list of the eight amphibians and fifteen reptiles that comprise the herpetofauna of the Hawaiian Islands. It includes comments on all of the non-marine species that are known to be established and the marine species occurring in the archipelago at the present time, together with brief historical accounts of these animals in the islands. A key for the identification of the forms is included to assist local students in recognizing the species encountered. The term "established" is used for those terrestrial and freshwater species that are represented by reproducing populations in the Hawaiian Islands.

The paper is based in part on field observations and a large collection made by one of us, Shaw, while stationed in the islands during World War II. These specimens are now in the private herpetological collections of Dr. Laurence M. Klauber of San Diego. In addition to this material, Dr. Harvey I. Fisher of the University of Illinois sent two collections from the islands to the American Museum of Natural History. These were recently made while Dr. Fisher was a member of the faculty of the University of Hawaii. He has also supplied us with additional specimens and pertinent information. The Shaw and Fisher collections comprise the primary basis for the report. Additional Hawaiian specimens in museums have been examined in some cases.

Stejneger's (1899) report on the land reptiles represents the earliest comprehensive treatment of the herpetofauna of the islands. McGregor (1904) and Snyder (1917) presented interesting data on the lizards of the islands, while Svihla (1936) listed some of the amphibians and described the life history of one of the frogs in detail. La Rivers (1948), in his general ecological notes on the fauna of the islands, included interesting field observations on a small number of amphibians and reptiles. In the report on his collections from the Pacific islands, Fisher (1948) included collecting localities and brief observations on the species that he obtained in the Hawaiian Islands.

Several general popular accounts of the Hawaiian herpetofauna have been included in the various natural history books on the islands, such as the works of Perkins (1903), Bryan (1915) and Tinker (1938; sec. ed., 1941). The last of these gives by far the best account of the amphibians and reptiles that has yet been published for the islands. Many Hawaiian forms are included in Loveridge's (1945) résumé of the reptiles of the Pacific world. Other accounts of species occurring in the islands are to be found in scattered scientific publications or are included in large works covering related groups. These references are included in the bibliography at the end of this paper.

For each species we have listed only a brief synonymy that indicates other names or name combinations by which the species has been cited in the literature and, where possible, at least one previous report of the species in the Hawaiian Islands. The scientific nomenclature used in the paper is in most cases that currently accepted by herpetologists. In the few cases where we do not follow the names used by the latest student of the group, we include brief comment calling attention to this fact.

We are indebted to many persons who have rendered assistance to us in connection with this study. We are grateful to Dr. Harvey I. Fisher, the University of Illinois, for permission to study his valuable collections, and for his pertinent observations and encouragement. We also owe a great debt of gratitude to Mr. Charles M. Bogert, the American Museum of of Natural History, for his many kindnesses and

help during the preparation of the report, part of which was prepared at that museum. The drawings illustrating the "key" for the identification of species were prepared by the Illustrators' Corps of the American Museum of Natural History, under the direction of Mr. Tom Voter. We wish to thank Mr. Paul Breese, Director of the Honolulu Zoological Park, and the late Edward L. Caum of the Hawaiian Sugar Planters' Association for their valuable assistance and encouragement. We desire especially to thank those who have lent us specimens from the collections under their care or who have provided us with pertinent information about specimens. Included in this group are: Dr. Doris Cochran, U. S. National Museum; Dr. Emmett Reid Dunn, Haverford College; Dr. Norman E. Hartweg and Dr. Charles F. Walker, Museum of Zoology, University of Michigan; Dr. Laurence M. Klauber, Zoological Society of San Diego; Mr. Arthur Loveridge, Museum of Comparitive Zoology, Harvard College; Dr. C. E. Pemberton, Hawaiian Sugar Planters' Association; Dr. Karl P. Schmidt and Mr. Clifford Pope, Chicago Natural History Museum; Mr. Joseph R. Slevin, California Academy of Sciences; and Dr. Elwood Zimmerman of the Bernice P. Bishop Museum, Honolulu. Mr. James W. Atz of the New York Zoological Society and Mr. C. B. Perkins of the Zoological Society of San Diego have read the manuscript and made helpful suggestions and comments, for which they have our sincere thanks.

Present Fauna

The amphibians and reptiles established in the Hawaiian Islands today represent a mere sprinkling of species in comparison with the herpetofauna of the mainland of the United States or Asia. The 23 recorded forms include eight species of frogs and toads, four species of turtles, two species of snakes and nine species of lizards. Three of the turtles and one of the snakes are marine species that occur over wide areas of the Pacific Ocean. Two other marine turtles, the Pacific Loggerhead and the Pacific Ridley Turtles, may appear occasionally in the islands as wanderers, but have not been definitely reported.

The eight species of frogs and toads represent three families, two of which are at present worldwide in distribution, the Bufonidae and the Ranidae. The third family, the Dendrobatidae, is represented in the Hawaiian Islands by the Gold and Black Poison Frog. This family is found only in the wet American tropical forests.

The marine turtles are representative of two families that occur in the warm seas of the world. These are the Cheloniidae, with two representative species, and the Dermochelidae, including only the Pacific Leatherback Turtle. The single freshwater turtle belongs to a family that has representatives in Africa, North America and southern Asia, the Trionychidae. The one marine snake is representative of a highly specialized family of venomous snakes, the Hydrophiidae, found in the warm waters of the Pacific and Indian Oceans. The single land snake belongs to an interesting family of burrowing snakes found in the tropical and subtropical parts of the world, the Typhlopidae.

The nine lizards belong to three families. The first of these is the family Gekkonidae, with representatives in the warmer parts of all the continents except Antarctica. Four species of Hawaiian lizards belong to this family. A single lizard species, the Cuban Anole, represents the family Iguanidae, pre-eminently a western hemisphere aggregation. Four species are members of the family Scincidae, which, like the Gekkonidae, has representatives on all the continents except Antarctica.

The land-dwelling reptiles include only small species and, except for one iguanid, are forms that also occur on other islands of the Pacific. The freshwater turtle attains a respectable size, with a shell length of more than 13 inches (330 mm) and weight of more than 18 pounds (Brock, 1947). It is used as food by some of the island inhabitants. All of the marine turtles are large in size and have been utilized in the economy of the islands. In the amphibians, two of the toads, the Asiatic and the Giant Neotropical Toad, are among the largest species of toad in the world, with a recorded maximum head-body length of nine inches (225 mm). The American Bullfrog, also, is known to reach this head-body length. The remaining species of frogs are of smaller size; nevertheless all seem to have been brought to the islands for economic reasons. Several species have played an important role in the economy of the islands, chiefly as food or in pest control.

Despite the fact that six lizards and one frog have at one time or another been described as new forms from the Hawaiian Islands, there are no endemic amphibians or reptiles on these islands. All of the species also inhabit other islands or regions. The new names that were proposed for material from the Hawaiian Islands are listed below. None of these is in current use, so the present name for each is indicated.

Amphibia

Bufo dialophus Cope, 1862; type locality: "Sandwich Islands," in error. =*Bufo quercicus* Holbrook. This species is native to the south-

eastern United States and is not known from the Hawaiian Islands.

REPTILIA

Dactyloperus insulensis Girard, 1857; type locality: "Sandwich Islands." =*Gehyra mutilata* (Wiegmann).

Doryura vulpecula Girard, 1857; type locality: "Sandwich Islands." = *Hemidactylus garnoti* Duméril & Bibron.

Hemiphyllodactylus leucostictus Stejneger, 1899; type locality: Kauai, Hawaiian Islands. =*Hemiphyllodactylus t. typus* Bleeker.

Leiolopisma hawaiiensis Loveridge, 1939; type locality: Oahu, Hawaiian Islands. =*Lygosoma* (*Leiolopisma*) *metallicum* (O'Shaughnessy).

Lygosoma cyanurum var. *schauinslandi* Werner, 1901; type locality: Molokai, Hawaiian Islands. =*Emoia cyanura* (Lesson).

Lygosoma vertebrale Hallowell, 1860; type locality: "Sandwich Islands." =*Lygosoma* (*Leiolopisma*) *n. noctua* (Lesson).

Origin of the Fauna

Much has been written relating to the geological history of the Hawaiian Islands and the origin of the land animals and plants now occurring there. An excellent summary of these studies, the data on which they are based and their conclusions, is presented in the introductory volume of "Insects of Hawaii" by Zimmerman (1948). We shall mention briefly the more pertinent points involved in outlining the origin of the amphibians and reptiles that now occur there. The evidence for these conclusions will be found in Zimmerman's paper and reference should be made to that work for a detailed account of the zoogeography of the archipelago.

The Hawaiian Islands are true oceanic islands that have never had any land connection with a continent since the rise of modern plants and animals. Thus all of the living land forms now occurring on the islands have reached there by travelling across the ocean from other land areas or are descendants of ancestral stock that succeeded in making such a journey.

Geographically the Hawaiian Islands are located closer to the continent of North America than to any other continental land mass. The coast of California is approximately 2,000 nautical miles east of the nearest of the islands. Unalaska to the north is slightly closer than California. The mainlands of Asia and Australia are twice as far away as the coast of North America. The mainland of North America and the Hawaiian Islands are separated by an uninterrupted expanse of sea. To the south and southwest of the Hawaiian archipelago are numerous clusters of islands that could serve as "stepping stones" from the Indo-Australian land areas. The closest of these islands to the Hawaiian group is the coral atoll, Johnston Island, 450 miles away.

Zimmerman divides the insect fauna of the islands into native and foreign elements. The native element is composed of endemic and indigenous forms. The endemics are those that are found only in the Hawaiian Islands. The indigenous forms are those that occur naturally in Hawaii and other places, but are forms that have reached the islands without the intervention of man. The foreign element also can be subdivided into two categories, the immigrant and the purposely introduced forms. Here the term "immigrant" is used for a form that is unintentionally brought to the islands by man. The "purposely introduced" category is obviously restricted to the group of organisms that man has brought to the islands intentionally.

Other categorizations of the fauna can be and have been recognized. These involve either differences in terminology or refinements that are unnecessary in the present discussion. We will, therefore, utilize Zimmerman's designations as defined above.

The endemic and indigenous forms that comprise the native land fauna are animals that are capable of dispersal across a broad saltwater barrier, or whose ancestors were capable of such dispersal. This dispersal may have been accomplished through the active movements of the animals themselves or may be the result of passive travel with the impetus provided by an agent other than the animals.

The difficulties facing land animals in travel across broad stretches of saltwater are great and few forms are capable of surviving such a trip. Thus the native (endemic plus indigenous) land fauna of the Hawaiian Islands is largely limited to a few groups of birds, insects and molluscs. Many of the large units of land animals have no native representatives in the islands. In each of these groups present there is a very high degree of endemism, reaching the amazing figure of approximately 99% of the native insects (Zimmerman, *loc. cit.*, p. 66).

These native land animals are descendants of ancestral forms that presumably came to the islands by means of their own powers of flight, were blown there by strong winds, were carried by debris floating on the sea, or were carried by other organisms. Such methods of dispersal are known to be effective for some animals. Apparently all of these methods have contributed to the formation of the present native land fauna. The abilities of the different animals to utilize the various methods of dispersal are indicated in part by the degree of success attained in colonizing the islands. The same dispersal

abilities have also determined the places from which the native land fauna is derived.

Present-day geographical and oceanographical conditions favor the dispersal of land dwelling animals from the west, southwest and south of the Hawaiian Islands rather than from the east or north. It is in the former directions that the shortest distances between adjacent land areas are to be found. The present prevailing ocean and wind currents are from the east of the islands, where a broad expanse of ocean lies. However, these currents are interrupted by cyclonic disturbances that set up counter currents from the west and southwest. These strong irregular currents, capable of carrying objects rapidly across shorter distances, may well be more effective agents of dispersal than the slower prevailing currents.

It is interesting to note the origin and relationships of the native Hawaiian plants and animals that have been studied in detail. According to Zimmerman (*op. cit.*), the Hawaiian flora consists of 92% Indo-Pacific derivatives, the native insects consist of 90% Pacific derivatives, and the native land snails consist of 70% Pacific affinities. Each of these groups exhibits a small number of forms that are American or Holarctic derivatives. In contrast to these groups, Mayr (1943) found that the native Hawaiian land birds showed a strong preponderance of North American elements. He calculated that the present land bird fauna is traceable to 14 separate colonizations. Omitting one element of doubtful origin, Mayr concluded that "eleven of the thirteen colonizations of Hawaiian birds probably come from North America and only two from Polynesia." Thus the birds are an exception among the native land plants and animals of the Hawaiian Islands. Of all the native land animals of the Hawaiian Islands, the birds would appear to be best equipped to traverse the broad expanse of saltwater separating North America from the Islands. For all other land animals, this extensive stretch of saltwater has been a formidable barrier to dispersal and is largely the reason for the small American affinities present.

With this brief résumé of the zoogeography of the Hawaiian Islands we can inquire into the origin of the amphibians and reptiles now dwelling there. As already stated, there are no endemic species of these animals in the islands. The only species that are definitely indigenous are the marine reptiles, consisting of three turtles and one snake. Thus none of the land dwelling amphibians and reptiles are here considered to be native species.

Amphibians, because of their naked skins and sensitivity to desiccation, are characteristically absent from oceanic islands. On the Pacific islands northeast and east of the continental island chains of the southwestern Pacific, (the New Guinea - Bismarcks - Solomons - New Caledonia-New Zealand axis, extending eastward to and including the Fiji Islands in the south), the only amphibian to be found is the Giant Neotropical Toad (*Bufo marinus*). This toad has been widely distributed by man throughout the Pacific to aid in control of insect pests on agricultural crops. There are no native frogs on these oceanic islands simply because frogs as a group are not adapted to dispersal across a wide stretch of saltwater.

Of the eight species of frogs and toads now occurring in the Hawaiian Islands, three are inhabitants of North America, two are from tropical America and three are from Asia, including Japan. All belong in the category of purposely introduced foreign species. The introduction of the five American species is clearly indicated in the historical record. Dr. C. E. Pemberton informs us that there is a statement in the Proceedings of the Royal Agricultural Society of Hawaii for 1855 to the effect that no frogs or toads occurred in the islands and that it would be advisable to introduce some. Jordan & Evermann (1905) stated that frogs were imported prior to 1867 and that some were brought from California in that year. In a later letter, Dr. Pemberton advises us that Albert Koebele, an entomologist employed by the Republic of Hawaii, made an extensive tour of Australia, Ceylon, China and Japan for the purpose of obtaining beneficial insects to introduce into the islands. The last portion of his trip consisted of a visit to Japan in 1895, returning to Hawaii in late 1895 or early 1896. He published a report on this tour, dated December 31, 1897, in which he states, "In addition to the numerous predaceous and parasitic insects, it was also found advisable to introduce Bats, Toads and Frogs . . . Several trials with Japanese Bats resulted in failure. On the other hand, Toads from California and Japan are breeding and the four species of Japanese Frogs no doubt as well."

Koebele does not mention the species of frogs and toads that he brought from Japan, but it seems likely that *Bufo bufo gargarizans, Rana n. nigromaculata* and *R. rugosa* were among them. They are well-known, common species in Japan. Today they are the only Asiatic amphibians living in the Hawaiian Islands.

Of the ten species of non-marine reptiles four appear to have been introduced within the last half century and are known at present only

from a single island within the Hawaiian archipelago. These are: the Cuban Anole, first found on Oahu in 1950; the Chinese Soft-shelled Turtle, reported for the first time in 1947 from Kauai; the Brahminy Blind Snake, first noted on Oahu in 1930; and the Metallic Skink, first collected on Oahu in 1917. The Cuban Anole is a close relative of the so-called "American Chameleon," *Anolis c. carolinensis* Voigt, of the southeastern United States, which is widely sold in pet shops, circuses and carnivals. When the supply of the lizards in the United States is low, large numbers of the Cuban relative are imported for the pet trade. There would seem to be little doubt that the small colony of the lizards now established in Honolulu is the result of escaped or released pet lizards. Thus this species is probably the only established land reptile that can be classed as purposely introduced—although this designation does not appear to be entirely correct, since the lizards were not introduced with the specific intention of establishing the species in the islands.

Brock (1947) has reported that the Chinese Soft-shelled Turtle was frequently imported into the Hawaiian Islands by orientals prior to World War II. Since the turtles are widely propagated for food in "turtle ponds" by both Chinese and Japanese in their homelands, it was natural to transport both the animals and the propagation custom to the islands. Thus this freshwater turtle is another purposely introduced reptile. To date this turtle is known to be established only on the eastern side of Kauai.

Neither the Brahminy Blind Snake nor the Metallic Skink has any recognized role in man's varied economic machinations, and it seems doubtful that either was brought to the islands intentionally. A small colony of the Blind Snake was discovered in the vicinity of the Kamehameha Boys School in Honolulu and until a few years ago it was known on Oahu only from this one locality. Investigations by several interested naturalists have indicated that the Blind Snakes were most probably brought to the islands in dirt around ornamental plants that were imported from the Philippine Islands for landscaping the campus of the school (Tinker, 1941).

The history of the Metallic Skink in the islands is not so easily discerned. It seems virtually certain that this lizard was not present prior to 1900. Today in collections from Oahu it is apt to be the most abundantly represented form. Outside of Oahu it is known to occur in Australia, Tasmania, the Loyalty Islands and the New Hebrides Islands. There would seem little likelihood that the lizard traveled unaided by man from its homeland to Oahu. It has been reported on none of the intervening oceanic islands and thus such a trip would have involved a journey of more than 3,000 nautical miles, a highly improbable feat. More likely the lizards reached the Hawaiian Islands in plant or wood imports from Australia.

The remaining seven species of lizards, four geckos and the three skinks, were all present in the Hawaiian Islands before the beginning of the present century and all are known to occur on more than one main island of the group. All of these species, except the Tree Gecko, occur over a wide area of the western and southwestern Pacific, occupying many oceanic as well as continental islands. Because of this distribution these species may be referred to as the Polynesian forms. The Tree Gecko has not been reported from as wide an area in the oceanic islands as the other species. Whether this indicates a more restricted distribution or a more elusive behavior is not known at present. All of the species occur in the East Indies and most of them occur on continental Asia. Systematic studies so far have disclosed no consistent differences that warrant nomenclatorial separation of the respective populations in the East Indies Islands and those in the oceanic islands thousands of miles to the east. Thus the East Indian lizards are specifically and subspecifically identical with their oceanic representatives. This suggests that the various island populations have not been isolated for a very long period of time in world history. If this isolation had been in existence for a relatively long period, it seems most certain that some of the species would have developed genetic differences setting them apart from their geographically distant relatives. With their wide dispersal through the Pacific oceanic islands, there are hundreds of small isolated populations of these lizard species, yet none of these has produced a distinctly different stock. This is in marked contrast to some congeners that are isolated on continental islands of the New Guinea-Bismarcks-Solomons-New Caledonia-New Zealand axis. Here a number of distinct populations have arisen (*vide* Burt & Burt, 1932, pp. 476-82).

Because of the wide dispersal through the oceanic islands of the Pacific and the absence of appreciable differentiation, most workers have concluded that these seven species of lizards were unintentionally transported by Polynesian man (Stejneger, 1899; Schmidt, 1930; Mertens, 1934). The prevailing ocean and wind currents are from the east and thus would not be conducive to drift dispersal. However, as mentioned earlier, strong counter currents are set up at times by cyclonic disturbances and these currents might be an important factor in propelling

drift objects from the west. It is entirely possible that some of the lizards may have travelled to the Hawaiian Islands by this drift method. The primary arguments against this view are: (1) that most of these species of lizards are found uniformly distributed through the oceanic area of the Pacific; (2) that the numerous isolated populations in this area are undifferentiated; and (3) that the same species are found on most of the islands. Haphazard drift dispersal of the lizards would probably not result in such a wide oceanic dispersal of the same species and would probably have produced some oceanic endemics.

In support of the theory of transportation from island to island by Polynesian man several facts can be mentioned. First, it is known that these people were excellent navigators who sailed throughout the oceanic islands of the western and southwestern Pacific. Secondly, the lizards that are characteristic inhabitants of the oceanic islands are either species that inhabit the ocean beaches or species that readily inhabit human dwelling places. Numerous investigators have reported seeing the lizard species discussed here in native canoes on the beach (Schnee, 1901; Snyder, 1917; Schmidt, 1930), laying eggs in native canoes on the beach (Snyder, 1917, p. 20), and actually being transported from island to island in native canoes (Woodford, 1895, p. 349). Writing in 1917 on the Hawaiian Lizards, Snyder (*op. cit.*) stated, "It would be quite impossible at the present time to provision and launch a large canoe without including both adult geckos and their eggs". Finally, transportation to the Hawaiian Islands by early Polynesian man, the first humans to visit the islands, would have brought this group of oceanic lizards there at a time in harmony with our present observations. Thus the species would be established prior to the arrival of Captain Cook in 1778 and yet this time would not have been of such duration as to have made probable the production of endemic descendants. The earliest visits of Polynesians have been estimated by anthropologists to have occurred in the twelfth century A.D. Using the radiocarbon technique, Libby (1951) would place the arrival date around the middle of the tenth century. In either case, it has been a relatively short period of time from an evolutionary standpoint.

If these lizards reached the islands with Polynesian man, it can be assumed that this was not an event that happened only a single time. Rather, as the habits of the lizards suggest, it probably took place a number of times. This is an important consideration in the evolutionary history of these lizards in the islands, since it means that they were not in complete genetic isolation from other conspecific populations.

If, as seems most likely, the seven species were brought to the islands by Polynesians, they were doubtless not imported intentionally and are thus to be classed as immigrants. This theory as to the origin of the four geckos and three of the skinks is based on indirect evidence, but seems to be the most probable explanation in view of our present knowledge.

In summary, all of the frogs and toads, the one freshwater turtle and one lizard are considered as purposely introduced foreign species. The single land snake and eight of the lizards are to be classed as foreign immigrants. Seven of the lizards are widespread oceanic island inhabitants that probably were brought to the Hawaiian Islands with the earliest human visitors, the Polynesians. There are no endemic nor indigenous land or freshwater amphibians or reptiles known to inhabit the Hawaiian Islands. The only indigenous reptiles are the three marine turtles and the one sea snake.

Modifications of the Fauna

As indicated in the preceding section of this paper, the terrestrial and freshwater amphibians and reptiles of the Hawaiian Islands have reached there in relatively recent years. Their occupancy of the islands has not been of sufficient duration to have produced endemic species. However, some differences have been noted in a few instances between the Hawaiian populations and the same species elsewhere. The differences discernible do not appear to us to warrant nomenclatorial recognition. These differences may result from genetic changes that are taking place in the populations, or merely from the chance restriction of genotypes among the limited number of original immigrants or introduced individuals.

In 1901 Werner recognized a new variety, *schauinslandi*, of the Azure-tailed Skink (*Emoia cyanura*) from Molokai. The differences indicated were in color pattern, with the proposed variety exhibiting a melanistic tendency. Snyder (1917) described two distinct color patterns in this lizard from Kauai and Maui, with one pattern being darker than the other and exhibiting minor differences in the longitudinal stripes. He further pointed out that the lighter pattern was found in lizards from the relatively dry lowlands, whereas the darker pattern occurs in lizards inhabiting the moist, wooded uplands. Stejneger (1899) had previously called attention to the existence of noticeable ontogenetic variation in color pattern in this species. The specimens examined by us support Stejneger's ob-

servation on the presence of a considerable amount of ontogenetic variation. However, as indicated by Snyder, the Azure-tailed Skink occurs in both the dry lowlands and in the moist, wooded uplands, and if the variation in color pattern is correlated with these different habitats, it may well indicate that two ecological races exist or are in process of arising. If the two color patterns do represent distinct forms, this would be an indication of differentiation occurring after colonization in the islands. Our ecological data are inadequate to evaluate this condition properly. Dr. Walter C. Brown, who has been studying the genus *Emoia,* will soon cover the status of these color variants in detail and in relation to the variation throughout the genus.

Comparison of Hawaiian Wrinkled Frogs (*Rana rugosa*) with specimens from Japan in the collections of the American Museum of Natural History indicates a number of minor differences. For example, the Hawaiian specimens are more heavily pigmented ventrally than the Japanese frogs. Thus on the venter they appear to possess light marks on a dark background, whereas the Japanese frogs appear to have scattered dark markings on a light background. The Hawaiian frogs have more extensive webs and less prominent outer metatarsal tubercles on the hind feet than are present in the Japanese frogs. These differences do not seem to warrant nomenclatorial recognition for the Hawaiian population, but suggest the possibility of some differentiation since the introduction of the species into the islands.

Minor differences of this nature are indicated in some of the other species. Statistical analysis of the variation in large series of several species might reveal more significant modifications that have taken place. The evaluation of all of these modifications should merit the serious attention of local students.

Changes in the Fauna

The animals and plants of the Hawaiian Islands have undergone marked changes since the first arrival of man. Insofar as the whole animal life of the islands is concerned, the primary changes have been those of the wholesale introduction of exotic species and widespread extermination of native elements. To illustrate the magnitude of the known introductions in two groups of animals, Fisher (1948) records 232 species of birds for the islands, of which 94 are exotic, and Zimmerman (*op. cit.*) calculates that of the more than 5,000 species of insects recorded, more than 1,300 species are foreign.

The extermination of the native elements was brought about mainly by the foreign animals that man has brought in, diseases brought with them, and the changes in the habitats that have occurred, rather than by man's direct predation of the fauna. Foreign birds have brought about the extermination of native bird elements in some instances, but probably of more importance in this connection have been the Mongoose (*Herpestes a. auropunctatus*), the cat (*Felis catus*) and the rat (*Rattus* spp.).

The land and freshwater herpetofauna is composed entirely of foreign elements and has continually increased in number of established species. When Stejneger (1899) published his paper on the land reptiles of the islands he listed only the seven species of lizards that comprise the Polynesian element of the reptile fauna. He did not list the frogs and toads that had been introduced prior to that date, although two or possibly three species apparently were definitely established at that time. The number of species of frogs and toads now established in the islands has increased to eight. The seven lizards have been augmented by one small snake, one freshwater turtle and two other species of lizards.

The forms listed above are the species that are known to be established in the islands. Several additional frog species and a number of turtles are known to have been introduced to the islands, but have not succeeded in forming reproductive populations.

Among the species of amphibians and reptiles that are known to have become established, there is one case in which a form may have disappeared subsequently from the islands. This appears to have been the fate of the Moth Skink, *Lygosoma* (*Leiolopisma*) *n. noctua,* at least on Oahu. It may still occur on some of the smaller islets of the archipelago or may be present in remote sections of the larger islands, but no Moth Skink has been collected in the past twenty-five years. Prior to 1900 it was the only member of the genus *Lygosoma* known to occur in the islands and was reported from Hawaii, Kauai, Maui and Oahu. It was sufficiently common on the last-named island to be represented in virtually all collections made there in earlier years.

About the time that the Moth Skink began to disappear from the islands, another species in the genus *Lygosoma* appeared in collections from Oahu. The Metallic Skink, *Lygosoma* (*Leiolopisma*) *metallicum,* was first collected in the Hawaiian Islands in 1917. In the last ten years it has been one of the most commonly collected lizards on Oahu, where it is locally very abundant. The question naturally arises as to whether there is any connection between the

apppearance of the Metallic Skink and the disappearance of the Moth Skink.

This is one of the most interesting and perplexing problems involving the herpetofauna of the islands. It is one that can only be answered by careful ecological and life history studies. Both species are primarily inhabitants of the lowlands. The Moth Skink is reported to occur most frequently along the beaches, whereas the Metallic Skink occurs from the coast into the interior valleys to an elevation of at least 1,500 feet. Both species are found frequently in the herbaceous ground plants and leaf litter. They are insectivorous and probably feed on any small insects that are available. The Moth Skink gives birth to its young, producing one or two at a time. The Metallic Skink lays eggs, numbering from one to four per clutch. The species are approximately of the same length, but the Metallic Skink appears to be slightly heavier.

From this limited knowledge of the life history and ecological requirements of the two species, can we obtain any clues relating to the disappearance of the Moth Skink? Aside from the remote possibility that the Moth Skink disappeared on Oahu because of an inherent loss of its reproductive capacity, there are several plausible explanations to account for its present absence.

The first explanation that comes to mind is that the Moth Skink was restricted to the immediate vicinity of the beaches. In the early stages of its colonization of the islands there was an abundant area of this habitat available. As the human population of the islands increased, more and more buildings were erected in the beach area, reducing the available habitat. This theory is based on the assumptions that this skink is rigidly limited to one particular habitat, that the habitat has been completely changed, and that the lizard is unable to live in association with man. These suppositions are not borne out by observations on the Moth Skink in other parts of its range. Also, there are still fairly sizable areas of this habitat on Oahu that are unoccupied by human beings, but in which there appear to be no Moth Skinks.

A second possibility is that the Moth Skink has disappeared as a result of predation. The introduced Mongoose, the cat and the rat are all known to prey upon lizards, at least occasionally. The larger frogs and toads might also be considered here, since they are known to eat small lizards. However, the infrequent presence of reptiles in the stomach contents of the frogs suggests that they are not serious predators of the lizards. The Mongoose is probably the most important of all these in relation to lizard predation. This mammal was brought to the Hawaiian Islands from Jamaica in 1883 and reputedly reached its peak of abundance around 1918. Predation pressure by the Mongoose on the Moth Skink may have been sufficient to depress the population to the point where it could no longer maintain adequate reproduction. If predation by the Mongoose is the sole or primary cause of extermination of the Moth Skink on Oahu, then this lizard should still exist on Kauai, on which island the Mongoose does not occur.

Perkins (1903) indicates that the rat has had a harmful effect on this lizard. Few data are available to evaluate the extent to which the rat preys upon lizards, but as a predator on these animals it appears to be of lesser importance than the Mongoose. Cats and some birds, also include an occasional lizard in their diet, but predation by these forms is probably too infrequent to be of importance.

The first of these two theories assumes that there is no relationship between the appearance of the Metallic Skink and the disappearance of the Moth Skink on Oahu. In either of these cases the Moth Skink presumably would have disappeared before the arrival of the Metallic Skink; the cause of the former's disappearance no longer exists or is ineffectual on the latter species. The third theory (below) assumes that the two species occurred in the islands at the same time for at least a brief period.

This last theory is that the Moth Skink disappeared as a result of competition between it and the Metallic Skink. Competition includes the complex of all direct and indirect disadvantageous relationships between two species. Its precise influence on a species' welfare is difficult to determine except in extreme cases. Crombie (1947) says that "related species which occur in the same area will tend to compete if the ratio of population to resources is high enough. It would then be expected that either one will completely eliminate the other from that area or that they will survive together by evolving some form of ecological isolation."

In the restricted habitats of oceanic islands competition may develop to a high degree. This has been an important factor in the evolution of many insular endemic forms. Cases of extinction as a result of competition are more difficult to recognize with certainty. Vesey-Fitzgerald (1948) suggests that some of the changes in the amphibian and reptilian fauna of the Seychelles are the result of interspecific competition. However, he does not elaborate on the details of this competition.

The fact that these two closely related members of the same genus are generally ground inhabitants of the lowlands, are both insectivor-

ous and are both of about the same size suggests that some degree of competition might exist between them in the islands. Competition between the two species as a result of similar ecological requirements would serve to emphaisize their differences in methods of reproduction. Live-bearing is generally considered a more effective method of reproduction than egg-laying because of the parental carrying of the embryos. The hazards to which the developing eggs are exposed are thus those affecting the gravid female. In oviparous species the eggs after deposition by the female are subject to destruction as a result of predation, desiccation, the effects of mold, or mechanical disturbance. These hazards are usually of sufficient magnitude to greatly reduce the number of eggs that complete development. However, we have no quantitative data available to indicate the relative success of these two methods of reproduction in a given habitat.

It seems certain that the relative success of egg-laying and live-bearing would vary under different circumstances. It is conceivable that under some circumstances oviparous reproduction would be more successful than viviparous reproduction (the term viviparous is used in a broad sense to include both viviparous and ovoviviparous methods). A majority of the Moth Skink females from the Hawaiian Islands have two young per female. Most of the preserved Metallic Skink females that contained undisturbed clutches had four eggs per female. If conditions in its habitat on Oahu permit most or all of the Metallic Skink eggs to hatch, then this species would have a reproductive advantage over the Moth Skink. To judge from the number of specimens of each in collections, the Metallic Skink is far more numerous and would appear to have been more successful than the Moth Skink.

It is, of course, possible that all three of these factors contributed to the ultimate fate of the Moth Skink on Oahu. Careful field studies by local naturalists should yield valuable information relating to this problem. Dr. Harvey I. Fisher, while a member of the faculty of the University of Hawaii, started a field investigation designed to obtain data on the breeding behavior, abundance and food habits of the skinks. Unfortunately this project was terminated by Dr. Fisher's move to the University of Illinois. It is hoped that future studies relating to this matter will be carried out in the islands.

Key for the Identification of the Fauna

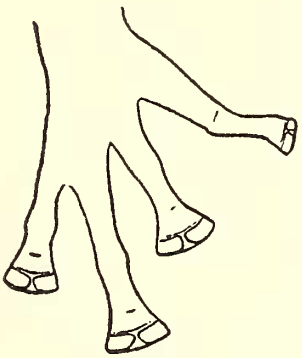
1. Scales absent; skin smooth or warty; tail absent in adults; hind limbs elongate, much larger than fore limbs (Frogs and toads)..2

   Scales present or body enclosed in a bony or leathery shell; tail present both in young and adults; hind limbs, if present, not or but slightly longer than fore limbs (Reptiles) 9

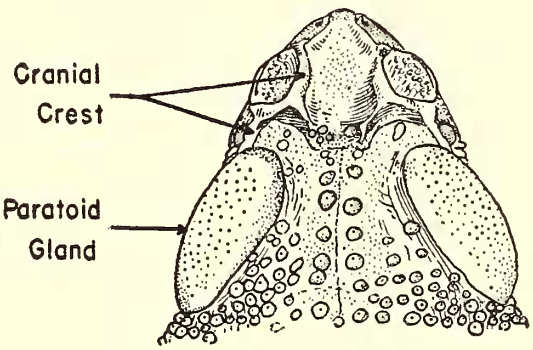
2. Tips of fingers and toes expanded transversely and bearing a pair of flaplike structures on upper surface (Text-fig. 1); dorsal coloration consisting of large, roundish, light (greenish-gold in life; white or light gray in preserved specimens) markings on a black background

   Dendrobates auratus

   Tips of fingers and toes not expanded transversely and without flaplike structures; coloration not a sharply contrasting pattern of large, roundish, light markings on a black background.....3



Text-fig. 1



Text-fig. 2

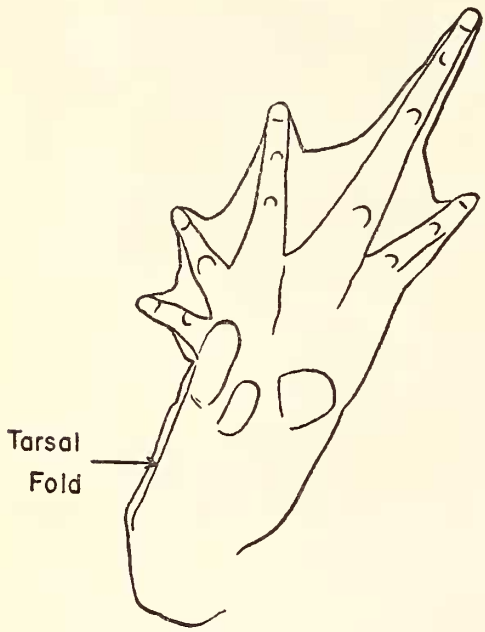
3. A large paratoid gland on each side behind the eye (Text-fig. 2); interdigital web of hind feet poorly developed (Text-fig. 3)..4

   No paratoid gland, interdigital web of hind feet well-developed (Text-fig. 4).....6

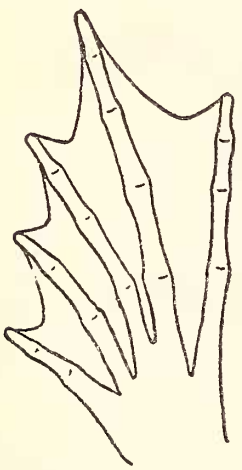
4. Prominent cranial crests present on dorsal surface of head (Text-fig. 2); paratoid glands not extending anteriorly above the ear opening but separated from the pos-

terior edge of the orbit by a distance equal to or greater than diameter of ear opening (Text-fig. 2).....*Bufo marinus*

Cranial crests absent or poorly developed; paratoid extending anteriorly above the ear opening and virtually bordering the posterior edge of the orbit.....5



TEXT-FIG. 3



TEXT-FIG. 4

5. A distinct fold of skin (tarsal fold) present on the inner side of the tarsus (Text-fig. 3); warts low and smooth
Bufo boreas halophilus

No fold of skin on inner side of tarsus; warts spiny, especially those on legs and belly.....*Bufo bufo gargarizans*

6. Numerous narrow, short longitudinal glandular ridges covering back and sides; numerous small warts on upper eyelid
Rana rugosa

Few, if any, longitudinal ridges; no warts on upper eyelid.....7

7. A prominent long glandular ridge on each side of the back extending from the eye almost to the hind leg.....8

No long glandular ridge on each side of the back.....*Rana catesbeiana*

8. A prominent, light mid-dorsal stripe and a more or less regular light stripe along each lateral glandular fold on the back
Rana n. nigromaculata

No distinct mid-dorsal or lateral stripes
Rana clamitans

9. Body enclosed in a bony or leathery shell; limbs paddle-shaped or with a prominent web between the digits (Turtles).....10

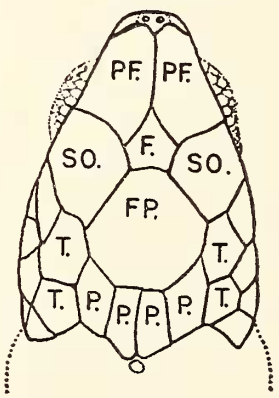
Body not enclosed in a shell; limbs, when present, not paddle-shaped nor with a prominent web between the digits (Snakes and lizards) 13

10. Body encased in a hard, bony shell.....11

Body covered by a leathery shell.....12

11. A single pair of prefrontal shields present on the head (Text-fig. 5); usually one claw on each fore limb.....*Chelonia japonica*

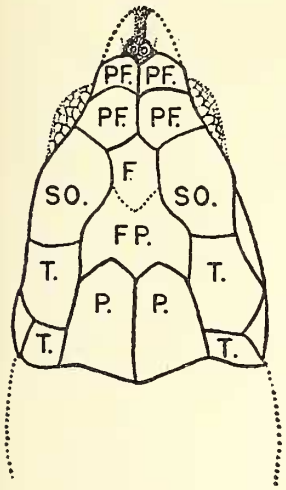
Two pairs of prefrontal shields present on the head (Text-fig. 6); usually two claws on each fore limb
Eretmochelys imbricata squamata



TEXT-FIG. 5

12. Upper shell with smooth skin showing seven prominent longitudinal ridges; limbs paddle-shaped; clawless; snout not projecting to form a soft proboscis
Dermochelys coriacea schlegeli

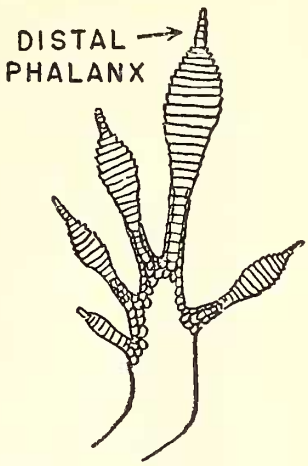
Upper shell soft and leathery, without



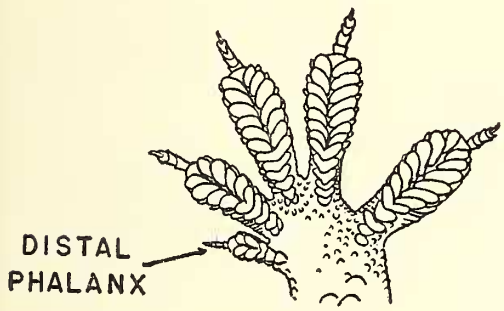
TEXT-FIG. 6

TEXT-FIG. 9

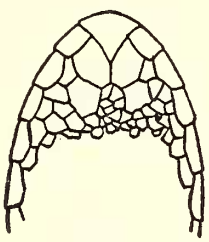
TEXT-FIG. 10



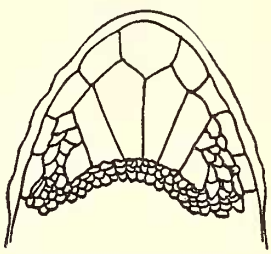
TEXT-FIG. 11



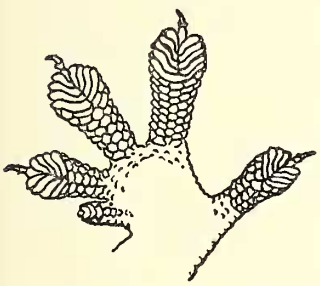
TEXT-FIG. 7



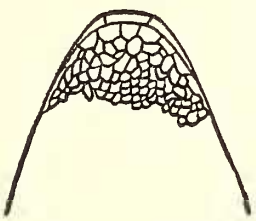
TEXT-FIG. 12



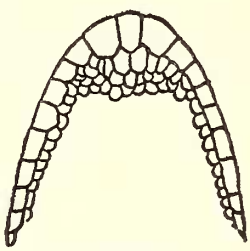
TEXT-FIG. 13



TEXT-FIG. 8



TEXT-FIG. 14



TEXT-FIG. 15

longitudinal ridges; limbs not paddle-shaped; with 3 claws; snout projecting to form a soft proboscis....*Trionyx s. sinensis*

13. With visible legs and with external ear openings 15

    No visible legs and no external ear openings 14

14. Tail strongly compressed laterally; eyes distinct; marine.....*Pelamis platurus*

    Tail rounded; eyes situated beneath a head shield, faintly visible; terrestrial *Typhlops braminus*

15. Fingers and toes expanded to form adhesive organs (Text-fig. 7-11).....16

    Fingers and toes not expanded.....20

16. Fourth toe of hind foot approximately twice as long as fifth toe (Text-fig. 11); pupil of eye round *Anolis carolinensis porcatus*

    Fourth toe not twice as long as fifth toe (Text-figs. 7, 8); pupil vertically elliptical 17

17. Chin shields bordering mental plate larger than first lower labial (Text-figs. 12,13)..18

    Chin shields bordering mental plate smaller than first lower labial (Text-figs. 14, 15) 19

18. Second largest pair of chin shields separated from labials by smaller scales (Text-fig. 12); inner digit with a distinct distal

phalanx bearing a claw (Text-fig. 7)
Hemidactylus garnoti

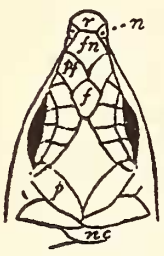
Second largest pair of chin shields broadly in contact with second lower labial (Text-fig. 13); inner digit lacks a distal phalanx and a claw (Text-fig. 8)....*Gehyra mutilata*

19. Two to four chin shields in contact with the mental plate and first labial on each side (Text-fig. 14); last phalanx of digits adhering to and not arising from within the expanded portion of the digits (Text-fig. 10).....*Lepidodactylus lugubris*

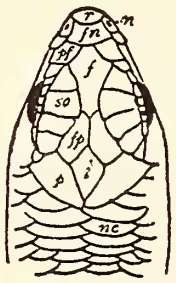
Six to seven chin shields in contact with the mental plate and first labial on each side (Text-fig. 15); last phalanx of digits free and not adhering to but arising from within the expanded portion of the digit (Text-fig. 9)..*Hemiphyllodactylus t. typus*

20. Eyelids vestigal, immovable; frontal shield separated from frontonasal shield by prefrontals which are in contact on mid-dorsal line of head (Text-fig. 16)
Ablepharus boutoni poecilopleurus

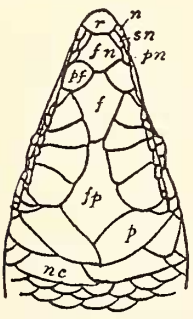
Eyelids well-developed, movable; frontal shield touching frontonasal; prefrontals not in contact on mid-dorsal line of head (Text-figs. 17, 18, 19).....21



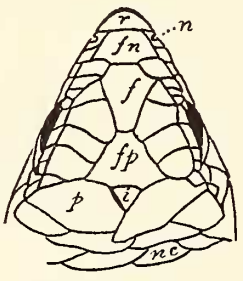
TEXT-FIG. 16



TEXT-FIG. 17



TEXT-FIG. 18



TEXT-FIG. 19

Abbreviations: *f*—frontal; *fn*—frontonasal; *fp*—fronto-parietal; *i*—interparietal; *n*—nasal; *nc*—nucal; *p*—parietal; *pf*—prefrontal; *pn*—postnasal; *r*—rostral; *sn*—supranasal; *so*—supra-ocular.

21. A supranasal shield present (Text-fig. 18); no interparietal plate (fused with fronto-parietal as shown in Text-fig. 18)
Emoia cyanura

No supranasal shield; interparietal plate present (Text-fig. 17).....22

22. Frontoparietal divided, forming two plates (Text-fig. 17); a prominent light occipital spot on posterior edge of interparietal and suture between parietals, usually continuing posteriorly as a narrow, light mid-dorsal stripe on the two median scale rows....*Lygosoma* (*Leiolopisma*) *n. noctua*

Frontoparietal a single plate, not divided (Text-fig. 19); no light occiptal spot nor a narrow light mid-dorsal stripe....*Lygosoma* (*Leiolopisma*) *metallicum*

AMPHIBIA

Order Salientia (Anura) — Frogs and Toads

In a tabulation of the Hawaiian fauna, E. H. Bryan, Jr. (*in* Fullway & Krauss, 1945), indicates that the number of species of amphibians is five plus, but does not list the species. We include eight species that are reported to be established in the islands at the present time. Additional species may be present in isolated colonies on the more remote islands. Some of the species listed here appear to have a limited distribution and thus their future status may be somewhat in doubt. Other species are known to have been brought to the islands but do not appear to have become established. For example, as already mentioned, it is known that Mr. Albert Koebele brought "Toads and four species of Japanese Frogs." Also, Mr. E. M. Ehrhorn is reported (Tinker, 1941) to have imported Australian Tree Frogs, *Hyla aurea*, and liberated them in the Manoa Valley on Oahu. These importations occurred in 1895 and 1929. Today there are three Japanese species established but no subsequent report of the Australian Tree Frog. There are doubtless many other similar cases in which the details are not known.

Family Bufonidae — Toads

BUFO BOREAS HALOPHILUS Baird & Girard
California Toad

Bufo columbiensis, Byran, W. A., 1915, Natural History of Hawaii, p. 384.

Bufo americanus, Tinker, 1941, Animals of Hawaii, p. 22.

Bufo boreas halophilus, Storer, 1925, Univ. Calif. Publ. Zool., vol. 27, pps. 169-182.

Both Bryan (1915) and Tinker (1941) record the introduction of toads by Mr. Albert Koebele. Bryan uses the specific name *columbiensis*, whereas Tinker employs the designation *americanus* but describes the animal as "the

little warty creature from California." We have examined no Hawaiian specimens that relate to the species in question, but we believe that the animal cited by Bryan and Tinker should be allocated under the name used here. Bryan's name is one that was used around the beginning of the century for both the California and the Northwestern Toad. Since Mr. Koebele obtained his specimens in California it is most likely that he had the California and not the Northwestern Toad. If the toads in question were native to California, as stated by both Bryan and Tinker, they were certainly not the American Toad. This last named species lives in the area east of the Rocky Mountains. Tinker's picture could be any one of the three toads mentioned, but looks more like an American than either of the other two species.

Mr. Koebele brought his toads to the Hawaiian Islands in the 1890s to assist in the control of noxious insects. Bryan (*loc. cit.*) states that it is now known definitely to occur only on the island of Oahu where he has seen specimens in the upper Manoa valley. It is certainly not very abundant at the present time. This, together with its limited distribution, makes its status as a member of the islands' fauna somewhat questionable.

Bufo bufo gargarizans Cantor
Asiatic Toad

Bufo asiaticus, Svihla, 1936, Mid-Pacific Magazine, vol. 49, no. 2, pp. 124-5, figs. 1-3.

Bufo bufo asiaticus, Tinker, 1941, Animals of Hawaii, p. 21.

Bufo bufo gargarizans, Boring, 1938, Peking Nat. Hist. Bull., vol. 13, pt. 2, pp. 89-110, tables i-ix.

Svihla (1936) appears to be the earliest specific recorder of the Asiatic Toad from the Hawaiian Islands. He states, "so far known to occur only on the Island of Kauai." Tinker (1941) reports a single specimen that was collected on Kauai in 1933. This is probably one of the Japanese toads that was imported by Koebele in 1895 or 1896 (see Origin of Fauna, p. 68). He stated in his 1897 report that the toads from California and Japan were breeding in the islands as of that date. He did not specify which species were included, but this is the only Asiatic toad present in the Hawaiian Islands today. The fact that it is now known only on Kauai suggests that it may have decreased in numbers in recent years. Like the Giant Neotropical Toad, this species was introduced to help control insect pests of agriculturally important plants. It is one of the largest toads in the world and consequently should be a voracious predator of insects. That such is true is indicated by the findings of Okada (1938) who made a careful study of the food habits of this toad in Japan. He found the stomach contents to consist of the following items:

Insects	98.4%
Myriapodes	1.0%
Molluscs	0.3%
Arachnids	0.2%
Plant material (probably taken unintentionally)	0.1%

Beetles made up the bulk of the insects recorded. A comparative study of the food habits of this toad and *Bufo marinus* in the Hawaiian Islands would be of considerable interest. It is possible that the two species are complementary in their distribution, with the Asiatic Toad occurring in the higher areas and the Giant Neotropical Toad inhabiting the lowlands. However, this is purely a supposition based on observations of the habits of the toads in their respective home areas.

The maximum size recorded for the Asiatic Toad is identical with the maximum size known for the Giant Neotropical Toad. Boring & Liu (1934) cite an unusually large specimen with a head and body length of 9 inches (225 mm). Females attain a larger size than males.

Boring (1938) and Pope & Boring (1940) discuss the systematic status of this toad, and we follow their treatment of the form.

Bufo marinus Linnaeus
Giant Neotropical Toad; Marine Toad

Bufo marinus, Pemberton, 1934, Hawaiian Planters' Record, vol. 38, no. 1, pp. 186-192, figs. 1-2.

This toad has been widely introduced throughout the tropical and semitropical areas of the world to aid in the control of insect pests that feed on important agricultural plants. It has probably been transported by man over a greater geographical area than any other amphibian, with the possible exception of the American Bullfrog. The Giant Neotropical Toad was first introduced into the Hawaiian Islands in 1932 when Dr. C. E. Pemberton brought 148 adult toads from Puerto Rico. Eighty of these were liberated in a taro patch near Waipio, Oahu, and 68 were released in a swampy part of the Manoa Arboretum at the head of Manoa valley, Honolulu. The toads increased rapidly in number and in a little over two years more than 100,000 descendants of the original stock were distributed through Dr. Pemberton's activities throughout the islands. The toads for most of the introductions of this

species in the Pacific area have come from the Hawaiian populations.

The effectiveness of the toad in checking injurious insects is clearly attested by an analysis of stomach contents. Illingworth (1941) and Fullway & Krauss (1945) indicate that in the Hawaiian Islands the toad is particularly valuable at the present time in destroying large numbers of the Rose Beetles (*Adoretus sinicus* and *Pantomorus godmani*) and the Burrowing or Surinam Roach (*Pycnascelus surinamensis*). Illingworth points out that destruction of the roach is a beneficial service since the roach is the intermediate host of the eye worm of chickens. Another beneficial service is performed by this toad in feeding on centipedes.

Reports on the diet of this toad in other areas show that virtually all small organisms may be eaten but the animals that form the bulk of the food consumed are (in the order of greatest frequence): beetles (adults and larvae); true bugs; cockroaches; moth larvae; slugs; snails; and millipedes. The insects reported in addition to those already mentioned for the toads include such economically important forms as the Army Worm (*Spodoptera exempta*), the Banana Borer (*Cosmopolites sordidus*), the Burnished Plant Bug (*Brachyplatys pacificus*), the Cane Beetle Borer (*Rhabdoscelus* or *Rhabdocnemis* sp.), the American Cockroach (*Periplaneta americana*), the Cutworms (*Cirphis unipuncta* and *Hippotion celerio*), the "Frenchi" Beetle (*Lepidiota frenchi*), the Grayback Beetle (*Lepidoderma* sp.), the Plant Bug (*Geotomus pygmaeus*), the Weevils (*Acalles* sp. and *Elytroteinus* sp.), and the White Grubs *Phyllophaga* sp. and *Rhopea* sp.),

Pemberton (1934) has presented a detailed account of the life history of this toad in the Hawaiian Islands. From his account it is interesting to note that the toad breeds throughout the year, has a larval (tadpole) stage lasting about 30 days and that sexual maturity is attained in approximately a year. Efforts to get the toads to breed in confinement have not been successful, although eggs laid in the wild can be hatched successfully and the tadpoles reared in hatchery pools. In fact, hatchery-reared tadpoles that were fed on special diets transformed in about 25 days, as compared with the usual 30-day larval period in the wild.

Ely (1944) has tested the saltwater tolerance of eggs and tadpoles of the species. He found that eggs deposited in dilutions of 15% or less of sea water would hatch and the tadpoles could be reared to metamorphosis. Eggs and tadpoles could not tolerate stronger dilutions of sea water. These experiments were performed at Honolulu, but specific salinity of the water was not recorded. La Rivers (1948) found the toad "present in numbers" in "a series of brackish lily ponds, adjacent, but without any direct connections to the Pearl Harbor fringe of tidepools."

Like the Asiatic Toad, this species is one of the largest toads in the world. A large female from British Guiana in the collection of the American Museum of Natural History has a head and body length of 9 inches (225 mm). The large size of this toad is an advantage in relation to insect consumption but has resulted in one of the objections raised against its introduction. On warm, rainy nights when the toads are active and are found crossing the roads in large numbers, they have been reported to present a minor hazard to automobile drivers. Another objection results from the fact that they can produce a powerful toxic secretion from the paratoid glands. This secretion is only effective when it comes in contact with mucous tissues, such as may occur when a dog bites a toad or when a human unintentionally rubs the secretion into the eyes after handling a toad. Small dogs have been known to die following attacks on toads. However, these represent extreme cases and death does not usually result from such experiences. In the case of a human being getting the secretion into the eyes, the result is a strong burning sensation accompanied by weeping and, frequently, sneezing. It should be stressed that this secretion is strictly a defensive device that is employed only when the toad is seized or handled.

La Rivers (1948) and Baldwin, Schwartz & Schwartz (1952) have pointed out that the Mongoose is a predator of this toad and is apparently unaffected by the paratoid secretions. The latter authors add that the few records of this toad in the stomachs of the Mongooses are not proportional to the abundance of the toads. Rather than attribute this discrepancy to any effectiveness of the poison, they suggest that the nocturnal habits of the toad may be responsible for the low degree of predation exerted on the amphibian by the essentially diurnal Mongoose. These authors report the interesting, unpublished experiments of Charles S. Judd of Honolulu who confined Mongooses and toads in the same cage, without food. At the end of his experiments, five Mongooses had eaten twenty toads and were "alive, saucy, active and in excellent health."

Another series of experiments conducted in Australia to test the possible undesirable effects of this toad on poultry were carried out by A. F. Bell (quoted by Lever, 1940). This

investigator found that there were absolutely no harmful effects to poultry as a result of the introduction of the toad. In one test "one fowl ate no less than 142 small toads within the space of about one hour" without exhibiting any harmful effects. To judge from the many reports on the effects of this toad in controlling injurious insects, the benefits that have resulted from its introduction appear to outweigh the minor objections that have been raised against it. Most of these objections have been shown to be based on insignificant or on entirely imaginary grounds.

Arnold (1944) reports an interesting cause of death in this toad in the Hawaiian Islands. In discussing the Strychnine Tree, *Strychnos nux vomica*, he states, "Dr. Harold Lyon (personal communication) states that a seasonal fatal epidemic among the toads (*Bufo Marinus*) [sic] in the Foster Gardens was due to the ingestion of *Strychnos* blossoms fallen from the tree. An analysis of these blossoms after drying showed that they contained 1.023% of strychnine....The bufoes died in convulsions. It is conjectured that either the toads eat the flowers instinctively because they fall near to them or that in catching an insect perched on a flower the latter is also ingested. The poisonous nature of strychnos flowers has not been recorded before to this writer's knowledge."

Known from the lowlands of Hawaii, Kauai, Maui, Molokai and Oahu.

Family Dendrobatidae — Dendrobatids

Dendrobates auratus Girard

Gold and Black Poison Frog

Dendrobates tinctorius, Tinker, 1941, Animals of Hawaii, p. 26.

Dendrobates auratus, Dunn, 1941, Copeia, no. 2, pp. 88-93.

Tinker (1941), using the specific name *tinctorius*, has recorded the introduction of this frog into Oahu in 1932 by Mr. David T. Fullway. Two hundred and six individuals were brought from Panama to assist in the control of insect pests. Dr. Emmett Reid Dunn has advised us that the specimens introduced into the islands were taken either on Taboga or Tabogilla Islands in the Gulf of Panama and were not from the mainland of Panama. These were liberated in the upper Manoa valley and apparently the frog has not spread far from this location. Eleven specimens were collected on May 28, 1944, near the head of the Manoa valley. They range in size from a snout-vent length of 26.6 to 32.0 mm. The largest individuals are females, two of which contain ripe eggs in the oviducts.

This frog represents an interesting addition to the Hawaiian fauna and is literally the most colorful amphibian found there. The striking coloration of light golden-green (white in preservation) rounded markings on a jet black background readily distinguishes it from any of the other frogs that occur in the islands. Like the other members of the genus *Dendrobates*, this species is noted for the highly toxic secretion of the skin glands. Dunn (1941) states that contact with it in a collecting bag is fatal to other frogs. Breder (1946) reports that the Indians of eastern Panama use these frogs to poison the tips of blow gun darts, by first toasting them over a fire. The skin secretion provides strong protection against predators but is harmless to man unless accidentally brought in contact with the eyes or the mucous membranes of the mouth.

Dunn (*loc. cit.*) has given an interesting summary of the life history of this species. One of the most interesting features of the breeding habits is the "tadpole carrying" that is performed by the males. In this performance the male frog has been found hopping about with one or more tadpoles securely adhering to his back. The males carrying tadpoles have been observed to enter and leave small water holes with their tadpole cargo still on their backs (Dunn), as well as to enter and deposit (or lose?) their tadpoles in the water (Eaton, 1941).

The species is diurnal in its habits, being most active in the morning after a rain. It may be observed about as frequently on the ground as in shrubs and bushes. The eleven specimens collected in the upper Manoa valley were found under a piece of tin beneath a house. From this material it is quite evident that the species is represented by a reproductive population, at least in the upper Manoa valley. Whether it has or will spread to other parts of Oahu remains to be seen. If it is able to increase its numbers and occupy additional areas, it should prove a valuable ally in the campaign to control insect pests.

In the past this species has frequently been confused with another member of the genus, *tinctorius*. The two species are easily distinguished by their coloration. As noted above, *auratus* has light rounded markings on a black background, whereas *tinctorius* has a light dorsolateral stripe on each side on a black background.

Known only on Oahu.

Family Ranidae — True Frogs

Rana catesbeiana Shaw

American Bullfrog

Rana catesbiana (sic), Bryan, W. A., 1915, Natural History of Hawaii, p. 299.

Rana catesbeiana, Storer, 1925, Univ. Calif. Publ., Zool., vol. 27, p. 279.

Rana catesbians (sic), Svihla, 1936, Mid-Pacific Magazine, vol. 49, no. 2, 124-5, figs. 1-3.

This was probably one of the first species of amphibians to be introduced into the Hawaiian Islands and may have been one of the frogs that was imported prior to 1867. During that year a shipment of frogs was brought in from California, but most of these do not appear to have lived. In 1879 six dozen frogs were brought to Hilo from Contra Costa County, California. These were said to be of two kinds, "one dark green and the other mottled" (Jordan & Evermann, 1905). This importation proved successful and the frogs soon became abundant. Like the Giant Neotropical Toad, the American Bullfrog has been transported by man over a great geographical area. The primary reason for transplanting the Bullfrog, however, was for the purpose of providing an additional source of food rather than for assistance in the control of injurious insects.

Bullfrogs consume large numbers of insects, but are not so effective in pest control as the toads because of their closer restriction to water. In addition to insects, the voracious Bullfrogs eat almost any animal that they are able to catch and can swallow. At Pearl Harbor, La Rivers (1948) found this frog to be common in "brackish lilyponds" that were otherwise quite barren of animal life. He was unable to determine their main source of food. Of eight stomachs examined, five were empty, one contained a Mourning Gecko, one a smaller Bullfrog, and one an American Cockroach. The eggs are laid in permanent ponds and it is reported (Tinker, 1941) that in the Hawaiian Islands the tadpole stage is completed in less than six months. In this area, Bullfrogs are preyed upon by Mongooses, Black-crowned Night Herons and cats, but man is by far the largest consumer of these frogs.

Jordan & Evermann (*supra cit.*) stated that the Bullfrog occurred in sufficient numbers to be marketed locally as early as 1900. Storer (1925), in speaking of this frog in the Hawaiian Islands, states that it "is now present in such numbers that it is sought commercially, and Hawaiian-grown Bullfrogs are to be found at times in the San Francisco markets." Svihla, writing in 1936, records the species but does not comment on its abundance. Tinker (1941) reports that it is found "on all the larger islands of our Territory" and records that the University of Hawaii has organized "frog clubs" to encourage the production of frogs for food.

The origins of the Bullfrogs introduced into the Hawaiian Islands are as uncertain as the date of the original introduction. As mentioned above, some of the frogs were brought from a frog farm in Contra Costa County, California. In connection with this story it is interesting to note a statement of Storer's (*supra cit.*) regarding this species in California. He says that the introduced Bullfrogs of California came from at least three sources: a New Orleans frog dealer; Missouri; and "the frogs at Standard are said to have been obtained from a San Francisco dealer who purchased his stock in Hawaii"!

It is quite possible that the Bullfrog is not so common today as it was a quarter of a century ago. Other frogs are present much more abundantly in recent collections from the islands than are specimens of this species.

Known from Hawaii, Kauai, Maui, Molokai and Oahu.

Rana clamitans Latreille

Green Frog

Rana clamitans, Tinker, 1941, Animals of Hawaii, p. 36.

The Green Frog has been reported from time to time, but its status in the islands is rather uncertain. We have examined no specimens of this species. It was possibly introduced at an early date along with Bullfrogs. Early reports of this frog may have been based on misidentified Bullfrogs; however, Tinker (1941) states that Mr. E. O. Farm made an importation of Green Frogs in 1935. These were liberated in his taro patches in the Pawaa section of Honolulu. The tadpole stage of the Green Frog requires a considerably shorter time than that of the Bullfrog, being between two and three months in duration.

At present known definitely only from Oahu.

Rana nigromaculata nigromaculata Hallowell

Black Spotted Frog

Rana nigromaculata, Tinker, 1941, Animals of Hawaii, p. 27.

Rana nigromaculata nigromaculata, Schmidt,

1927, Bull. Amer. Mus. Nat. Hist., vol. 54, p. 563.

The only record of the occurrence of this species in the Hawaiian Islands is that of Tinker (1941). He states that it was supposedly introduced sometime after 1925 and that it is now found to be "commonest" in the streams around Honolulu and in the lowland areas about Waipahu on Oahu. We have not seen any specimens of this frog from the islands.

The Black Spotted Frog is a native of China and Japan. Schmidt (1927) proposed the recognition of three subspecies, but Liu (1950) questions that such treatment is justified in light of our present knowledge. Moriya (1952), in his current studies on this frog in Japan, confirms Schmidt's recognition of several races. It is not known definitely whether the Hawaiian frogs were brought from China or Japan, but there is the possibility that this was one of the four species of Japanese frogs brought to the islands in 1895 or 1896 by Koebele. Tinker's report suggests that it may have been brought in more than once. It is not a well-known species in the islands and does not appear to be very common. In the Orient it is found in the vegetation around ponds, streams and flooded rice fields.

Rana rugosa Schlegel

Wrinkled Frog

Rana rugosa, Svihla, 1936, Mid-Pacific Magazine, vol. 49, no. 2, pp. 124-5, figs. 1-3.

The first specific report of this species in the Hawaiian Islands is that of Svihla (1936), although Pemberton's (1934) article on the Giant Neotropical Toad suggested its presence. Dr. C. E. Pemberton generously searched the published records for us to obtain information relating to the introduction of this species. He had personally been familiar with it in the small streams on Oahu since 1913. Tinker (1941) stated that "it made its way into the Islands sometime prior to 1900." In the "Report of the Minister of the Interior to the President of the Republic of Hawaii for the Biennium ending 1897," Dr. Pemberton found the interesting and suggestive report of Albert Koebele's trip to Australia and the Orient. This trip ended with a visit to Japan where Koebele secured a number of animals for importation to Hawaii. Included in his collection of live animals were toads and "four species of Japanese Frogs." Koebele returned to Hawaii in late 1895 or early 1896. It seems very probable that *Rana rugosa* was one of the species brought in at that time and, to judge from its local abundance on Oahu, it has been the most successful of the amphibian introductions from Asia.

Svihla has presented a detailed life history account of the species in the Hawaiian Islands and listed it from Maui and Oahu where it is found in the mountain streams. Fisher found adults and tadpoles on June 11, 1947, in the Makiki Stream at elevations of 400 to 1,000 feet in the Makiki valley on Oahu. He says (*in litt.*) that this stream is "a completely shaded mountain brook with large boulders in its course. The water is rather fast moving but there are a few pools up to four feet in depth. Grasses, weeds, and trees grow in the water; it is around the heavily overgrown shallow pools that the frogs are most numerous. Their habits seem to be much like those of *Rana pipiens*."

Fisher has received reports from competent observers that this species is also present on the island of Hawaii and that it breeds from February to August. In 1947 on Oahu he found the Wrinkled Frog breeding from February 15 to July 15 and collected a good series of tadpoles on June 11, 1947, in the Makiki Stream. The tadpoles varied in total length from 8.0 mm to 43.0 mm. These seemed to represent three different age groups. Those from 31 to 43 mm possessed external hind legs. The body length of the 43.0 mm specimen was 16.2 mm. This individual is below the size at which metamorphosis reputedly takes place. Okada (1931) records tadpoles of 72-76 mm in total length. Newly transformed juveniles collected on the same date as the Mikiki valley tadpoles have a head and body length of 19.5 to 26.8 mm in total length. Seven adult females vary in head and body length from 38.3 to 48.0 mm. Six of these possess ripe eggs in the oviducts. A single adult male, with a head and body length of 37.0 mm, was collected.

According to Okada's data for Japan, males average 44.7 mm and females average 42.8 mm in head and body length. The Hawaiian specimens collected by Fisher exhibit several minor differences in coloration and morphology from Japanese material in the collection of the American Museum of Natural History. However, these differences do not appear to warrant nomenclatorial recognition for the Hawaiian population. Moreover, Okada indicates that the species exhibits considerable variation in different parts of Japan.

Okada (1938) has shown that this species of frog includes a higher percentage of insects in its diet than any other Japanese frog studied. His analysis discloses the following materials in the stomachs (as copied from Okada):

Insects	98.4%
Crustaceans	1.5%
Molluscs	1.0%
Segmented worms	0.5%
Plant material	0.5%

Of the insects consumed, most were beetles, of which approximately two-thirds belonged to noxious species. In Japan the Wrinkled Frog is very common in the paddy-fields, where it is of great value in checking the insect pests of rice. This frog is also used as food by the Japanese and is sold in the markets.

Known from Hawaii, Maui and Oahu; reported to be present on Kauai.

REPTILIA

Order Chelonia — Turtles

At the present time three species of marine turtles have been reported from the waters surrounding the Hawaiian Islands and at least one introduced species of freshwater turtle has become established on the island of Kauai. There are no native land or freshwater turtles on the islands. Two additional marine turtles, the Pacific Loggerhead and one Pacific Ridley, may reach the islands as occasional wanderers.

A wide variety of land and freshwater turtles has been brought to the islands, but except for the Chinese Soft-shelled Turtle none of these appears to have founded self-maintaining colonies. Giant Galapagos Turtles (*Testudo elephantopus* subsp.) were brought to the islands between 1812 and 1825. Some of this original group were still alive in 1915 (Bryan, 1915), and the last one died in the 1930s (Breese, *in litt.*) This large land turtle has not become established and the only specimens known in the islands today are those in the Honolulu Zoo.

A number of species of freshwater turtles from the United States have been introduced into the islands as part of the "pet turtle" trade. Some of these have been kept in private fish ponds, but so far there is no evidence that any species has become established. The most frequently involved species are the Red-eared Turtle, *Pseudemys scripta elegans* (Wied), and the Common Map Turtle, *Graptemys geographica* (Le Sueur).

Family Cheloniidae — Marine Turtles

Chelonia japonica (Thunberg)

Western Pacific Green Turtle

Chelonia agassizii, Grant, 1927, Copeia, no. 164, p. 69.

Chelonia mydas, Tinker, 1941, Animals of Hawaii, p. 45.

Chelonia japonica, Carr, 1942, Proc. New Eng. Zool. Club, vol. 21, p. 3.

The correct name for the Hawaiian Island Green Turtle is somewhat problematic. At the present time one of us, Shaw, is studying the systematics of the marine turtles of the eastern Pacific region. From the data obtained so far and on the basis of the zoogeographic considerations outlined by Schmidt (1945), it appears that the Hawaiian Islands represent the easternmost outpost of the Western Pacific Green Turtle. The detailed results of Shaw's studies on the marine turtles will be presented at a later date.

This species is the most abundant of the marine turtles in the Hawaiian area. Green Turtles, like the other species of marine turtles, usually come ashore only when the females come out of the water to lay their eggs, as they do on French Frigate Shoal. Wetmore (*in* Mellen, 1925) reported killing females that "contained eggs ready to be laid." Wetmore (1925), Mellen (1925) and Grant (1927) have reported the exceptional habit of this species of basking and sleeping out of the water on secluded beaches and rocks along the more remote, less inhabited islands of the Hawaiian group. A photograph taken on Laysan Island in 1893 and published in the New York Zoological Society Bulletin, vol. 16, no. 60, for November, 1913, shows three Green Turtles on their backs on the beach. The accompanying article does not state whether the turtles were turned while laying eggs or while sleeping on the beach. Ida M. Mellen (*supra cit.*) elaborated on the habits of the marine turtles sleeping on land in the Hawaiian Islands and quoted additional details from her correspondence with Dr. Wetmore. The latter stated, "I frequently saw from 25 to 50 or more on the beaches at one time." He also emphasized the point that this appeared to be a daily occurrence on uninhabited beaches and rocks.

Tinker (1941) reports a 50-pound Green Turtle that was removed from the stomach of a large Tiger Shark caught off Barber's Point, Oahu, on February 28, 1935.

Eretmochelys imbricata squamata Agassiz

Pacific Hawksbill Turtle

Chelone imbricata, Bryan, 1915, Natural History of Hawaii, p. 299.

Eretmochelys imbricata, Tinker, 1941, Animals of Hawaii, p. 49.

Eretmochelys imbricata squamata, Carr, 1942, Proc. New Eng. Zool. Club, vol. 21, p. 4.

Next to the Green Turtle, the Hawksbill is the commonest turtle in the vicinity of the

Hawaiian Islands. This turtle has little economic importance today, although formerly it was hunted rather widely for the "tortoise shell" of commerce.

Tinker (1941) states that it is "seen commonly in the waters about the Hawaiian Archipelago."

Family Dermochelidae — Leatherback Turtles

DERMOCHELYS CORIACEA SCHLEGELI (Garman)

Pacific Leatherback Turtle

Sphargis coriacea, Tinker, 1941, Animals of Hawaii, p. 41.

Dermochelys schlegelii, Stejneger & Barbour, 1943, Check List. N. Amer. Amphibians and Reptiles, p. 211.

Dermochelys coriacea schlegelii, Carr, 1952, Handbook of Turtles, p. 452.

This species, the largest of all living turtles, is not common in the vicinity of the Hawaiian Islands and the few specimens recorded from there have probably been wanderers that reached the area accidentally. Tinker (1941) reports that one was caught "about 15 miles off Kailua on Windward Oahu" on April 5, 1935, and was brought into the fish market in Honolulu three days later. Mr. Breese advises us that one was caught off Oahu this year.

Family Trionychidae — Soft-shelled Turtles

TRIONYX SINENSIS SINENSIS Wiegmann

Chinese Soft-shelled Turtle

Trionyx sinensis sinensis, Smith, 1931, Fauna Brit. India, Reptilia and Amphibia, vol. I, p. 176.

Trionyx sinensis, Brock, 1947, Copeia, no. 2, p. 142.

The presence of this Chinese turtle in the Hawaiian Islands was first reported by Brock in 1947. It is known to be established only on the eastern side of Kauai. Both the Chinese and Japanese make wide use of the soft-shelled turtles as food and have propagated some species in turtle ponds. These turtles were frequently imported into the Hawaiian Islands for food purposes and the Kauai turtles doubtless owe their establishment to propagation efforts by the Orientals. The success of these efforts was achieved prior to World War II when importation from the Orient was interrupted. Brock reports that during the war the local price reached six dollars per pound. It will be interesting to note how rapidly the propagation and/or occurrence of this turtle will spread to the other islands of the Hawaiian archipelago.

Order Squamata

Suborder Serpentes — Snakes

Only two snakes are known from the Hawaiian Islands. One of these is a sea snake that is seen occasionally in the seas around the islands. It is a venomous snake that virtually never bites a human for the simple reason that humans seldom come in contact with it since it does not come in to the land. The other snake is the Blind Snake, a small burrowing species less than a foot in length. This is the only land snake found in the Hawaiian Islands and it occurs there only in a restricted section of Honolulu.

Family Typhlopidae — Blind Snakes

TYPHLOPS BRAMINUS (Daudin)

Brahminy Blind Snake

Typhlops braminus, Slevin, 1930, Copeia, no. 4, p. 158.

This small, secretive snake was apparently introduced from the Philippines in the dirt surrounding plants that were brought in for landscaping the campus of the Kamehameha Boys School in Honolulu. It was first found there in January of 1930 and appears still to be restricted to this general area, although definitely increasing in numbers. Fisher (1948) reports specimens from St. Louis Heights, Wilhelmina Rise and the lower Manoa valley, all in Honolulu.

In 1944-45 small colonies of this snake were thriving, but local naturalists were concerned that an overzealous collector might unwittingly destroy them. The snake is usually found in or under logs and stumps, under boards, rocks or debris of various kinds. It is rarely found abroad but has been seen out following heavy rainfall. Cagle (1946-b) reports that a female collected in Tinian, in the Marianas, laid three elongate eggs on April 21, two of which hatched on May 29; the embryo in the third egg died during development.

Family Hydrophiidae — Sea Snakes

PELAMIS PLATURUS (Linnaeus)

Yellow-bellied Sea Snake

Hydrus platurus, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21, p. 785.

Pelamis platurus, Smith, 1926, Monograph of the Sea Snakes (Hydrophiidae), London, p. 116.

Sea snakes are rare in the vicinity of the

Hawaiian Islands. Stejneger (1899) states with surprise that he could find no record for this species in Hawaiian waters. Bryan (1915) records three specimens that he cites as "the first sea-snakes to be taken in Hawaii." This species is frequently found in open water, but the viviparous (= ovoviviparous) females are reported to bring forth their young on the remote rock islets and reefs. The late Edward L. Caum checked the accession records of the Bishop Museum up to 1944 and found that four specimens had been recorded. All were taken in the waters off Oahu. No date of collection is recorded for two of the specimens, while two were collected "prior to 1921."

Order Squamata

Suborder Sauria — Lizards

In terms of abundance and ubiquity, the lizards are the most prominent members of the amphibian and reptile fauna of the Hawaiian Islands. Among the terrestrial element of this fauna, the lizards are also the oldest inhabitants of the islands, predating the immigration of European or Asiatic peoples to the islands. For these reasons they have been studied more and are better known than the other reptiles or the amphibians. Because of their predominantly insectivorous diet, lizards are highly beneficial.

The nine species of lizards now known from the Hawaiian Islands belong to three families: Gekkonidae, Iguanidae and Scincidae. All four species of geckos and three species of skinks are widely distributed throughout the warmer oceanic islands of the Pacific. On many of the islands these seven species represent the entire terrestrial reptile fauna. From the available information it seems certain that these lizards owe their wide occurrence in the Pacific area to being transported by Polynesian man. The remaining species of skink and the single iguanid lizards have reached the Hawaiian Islands since the beginning of the present century. Neither of these last two forms is part of the widespread Pacific island fauna.

Family Gekkonidae — Geckos

Lepidodactylus lugubris (Duméril & Bibron)

The Mourning Gecko

Lepidodactylus lugubris, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21, p. 792.

The Mourning Gecko is the smallest of the Hawaiian geckos. Adults have been observed with a total length of three and a half inches, with the tail comprising nearly half of the length (head-body length 44 mm and tail length 41 mm). It is a common species on several of the Hawaiian Islands. On Oahu it is the most commonly observed gecko. In Shaw's collection of 239 geckos from that island, approximately 60% were Mourning Geckos. Snyder (1917) reports an even greater preponderance of this form among the species that he observed on Oahu. Near Honolulu he collected 107 lizards in about two hours; 102 of these were Mourning Geckos. On another occasion, he took 147 geckos of which 144 belonged to this species. Snyder correctly cautions that "The collector's catch should not be regarded as an index of the relative abundance of a species, and in this particular case it appears that the gregarious habit of the form was largely the cause of its being caught in such numbers." Of course, other factors will also operate to make it impossible to use the number of specimens collected as an accurate indication of actual abundance. These include time of day, weather, season, method of collecting, size, color, habits and habitat of the animal. Snyder calls attention to an interesting difference between the Fox and Mourning Geckos: "Geckos of a more wary nature, and those which closely resemble the bark of trees both in the color and roughness of the skin, are apt to be overlooked. *Hemidactylus garnoti*, for example, is well protected in this way, and moreover it seems to be possessed of keen vision, is cautious of danger, and swift in flight, frequently gliding like a flash from among other geckos which remain undisturbed at the approach of danger." Another difference is that the Mourning Gecko is more commonly found in open, non-forested areas, whereas the Fox Gecko appears to be primarily an inhabitant of forested regions.

In Snyder's first quotation above the gregarious nature of this gecko is pointed out. As many as 20 individuals have been found under a single large strip of bark on the trunk of an Algaroba tree at Puuloa Point on Oahu. Like most other geckos, this species is primarily noctural, although individuals may be seen at all hours of the day — even basking in the sun (La Rivers, 1948). In the upper Manoa valley these lizards were commonly seen at night on or near window screens and on the exteriors of buildings, often congregated in the vicinity of lights to which insects were attracted. At Puuloa Point they were abundant on the trunks of the Algaroba trees, foraging for food. During a considerable amount of night collecting "eyeshine" was only observed twice in this species, the eye being a brilliant reddish-orange.

This gecko is one of the noisy species, often

being heard "chirping" at night, especially near lighted areas. Several Mourning Geckos were kept together in a gallon jar at Pearl Harbor. There was a considerable amount of "chirping" back and forth among them, and one, perched high on the sides of the jar and about three inches from another, "chirped" at the other several times. Then it made a quick dash, biting its neighbor on the side of the body and emitting a prolonged "chirp" at the moment of contact.

As is true of virtually all geckos, the normal complement of eggs per female is two. In this species the egg shell is soft, pliable and moist when first laid, becoming hard and dry after a short exposure to the air. The eggs adhere to any object with which they are in contact when first laid and retain any indentations made while pliable. Thus the typical clutch of two is usually found closely adhering to one another and to the surface on which they are laid, being conspicuously flattened along the adhering surfaces.

On October 1, 1944, a large female was collected at Pearl Harbor, apparently in the process of depositing her eggs in a small opening in a Banyan tree limb. The opening already contained two adhering eggs in one corner and a single egg to one side of these. The single egg appeared to have been freshly laid and may have been deposited by the female collected. At the time of collection the female had the posterior half of her body in this cavity and only one egg was found in her body. On October 10, 1944, the female was killed and the single egg was squeezed out through the cloaca. When first exposed the shell was soft, pliable and moist. It had become dry and firm but not completely hardened in 30 minutes. In testing the pliability a slight rupture was made, so that the egg was then opened. It contained a small embryo with distinct eye spots and slowly beating heart. It is possible that this development was the result of delayed oviposition, or it may indicate retention of eggs until embryonic development is well advanced, as has been reported in some lizards (Kauffeld, 1943).

The eggs are laid in a variety of situations that provide primarily an absence of direct sunlight: under logs, boards and rocks; in crevices; in, under and on the fronds or bases of large leaves; on protected portions of trees, buildings and fences; in unused key holes and door locks; on the underside of vehicles and boats, in lumber and rock piles; and even on infrequently used clothing stored in dark closets. Although the eggs are usually laid in a situation protected from the sun, Cagle (1946-a) found four eggs deposited on a leaf in such a position that they were exposed to the direct rays of the sun throughout most of the day. Such exposed eggs are doubtless killed by the resulting high temperatures.

Snyder reports the size of the eggs to vary from 6.2 to 6.8 by 8.8 to 9.2 mm. The period of incubation varies according to the temperature and the length of time that the eggs are carried by the female before being laid. A captive female laid one egg in a glass jar on January 31, 1945. The egg and jar were placed in a dark closet and left until May 3, 92 days later, when the egg was opened for examination. It was found to contain a live, almost completely developed embryo and only a small amount of yolk. This incubation period seems unusually long, probably because of a lower temperature prevailing in the closet than in the outdoor situation. An incubation period between one and two months would seem to be more common.

The newly hatched young are reported to have a total length of 31 to 38 mm (Snyder). They also are said to be more diurnal than the adults, often being seen abroad when the adults are secluded. In the Hawaiian Islands this gecko breeds throughout the year and there seems to be no definite peak in mating activity.

Examination of the stomach contents of preserved specimens disclosed cockroaches, moths, mosquitos and ants. Observations on these geckos feeding at night near lighted window screens show that they may catch their prey in one of two ways. Sometimes the insects, principally moths, were stalked across the screens, with the geckos approaching cautiously to within a short distance and then making a short dash to grab the prey. More often the geckos remained concealed from view just off the lighted screen surface, waiting for an insect to approach within easy reach and then dashing into the lighted area to grab the insect and quickly return to the darkness. One individual was observed to capture food by drawing the body into a somewhat S-shaped position from which it made sudden thrusts or "strikes" at insects that approached within range. There was no apparent forward leap, but rather a quick forceful straightening of the gecko's body. La Rivers (*op. cit.*) tabulated 35 species of arthropods that he found in the stomachs of 38 Mourning Geckos. Cockroaches of several species and a number of different beetles were the most frequently-encountered insects in these stomach contents. He also recorded a number of field observations on the feeding habits of this gecko, and

was particularly impressed with its visual acuity under "minute quantities of light too faint to stimulate strictly diurnal retinas."

La Rivers reported that this gecko, together with several of the other lizards, comprises an important part of the diet of the introduced Mongoose (*Herpestes a. auropunctatus*). He also found Mourning Geckos preyed upon by the American Bullfrog (*Rana catesbeiana*), a Praying Mantis (*Tenodera angustipennis*) and a spider (*Metargiope trifasciata*).

The Mourning Gecko has been collected on Hawaii, Kauai, Maui, Molokai and Oahu.

Hemiphyllodactylus typus typus Bleeker
Tree Gecko

Hemiphyllodactylus leucostictus, Stejneger, 1899, Proc. U. S. Nat. Mus., vol 21, p. 800, (type locality: Kauai, Hawaiian Islands).

Lepidodactylus crepuscularis, Perkins, 1903, Fauna Hawaiiensis, vol. 1, pt. IV, p. 367.

Hemiphyllodactylus typus, Brongersma, 1932, Zool. Med. Rijks. Mus. Nat. Hist. Leiden, vol. 14, p. 6.

Hemiphyllodactylus typus typus, Smith, 1935, Fauna of British India, Reptilia and Amphibia, vol. 2, p. 107.

This is the least commonly observed gecko of the Hawaiian Islands. It is of moderate size, being smaller than the Fox Gecko but larger than the Mourning Gecko. It has been reputed to reach a length of four and three-quarters inches, with the tail comprising half of this length (head-body length 60 mm; tail length 60 mm). This species appears to be entirely arboreal and nocturnal in habits. Specimens were collected in the drier, coastal regions, as well as in more humid sections at the foot of the mountains. In contrast to the other geckos, the Tree Gecko appears to avoid buildings, fences and other man-made habitats. A number of these geckos were collected on Oahu. They were found under the bases of coconut palm fronds, under the bark and in small holes on Algaroba trees, and at night on vines. At Barber's Point many were found during the day by stripping the bark from the horizontal limbs of fallen trees. Despite the fact that numerous individuals were seen, only a few were collected because of their quick escape reaction. As soon as the bark was lifted, the geckos would quickly run from under the bark and jump from the limb, a height of four feet from the ground.

The tendency of this gecko to avoid the man-made habitats and its quick escape reaction are largely responsible for its poor representation in collections from the Hawaiian Islands. Of the 239 geckos that were collected on Oahu, only 14 belong to this species. Stejneger (1899) had 69 geckos from the Hawaiian Islands and only 7 belonged to this species.

One of the Tree Geckos kept in a glass jar with several other geckos would "chirp" several times at a Mourning Gecko and then stealthily crawl towards it, nipping it a couple of times along the side of the body until it was driven to another part of the jar. This was repeated on several occasions.

The eggs of this species are smaller and more yellowish in color than the eggs of the other geckos found in the islands. Snyder (*op. cit.*) gives their size as 5.7 to 6.6 mm. They are usually laid in clusters of two, adhering to one another but not always adhering to the surface on which they were deposited. On Oahu eggs were found in holes in the trunks of trees, between the frond bases and trunks of coconut palms, under strips of bark and also in the fractured stubs of large branches.

Snyder reports the newly hatched young as measuring 29 mm in total length and 15.5 mm head-body length.

Stomachs of adults examined from Oahu contained numerous small snail shells, cockroaches and flies.

Stejneger (*op. cit.*) proposed the name *Hemiphyllodactylus leucostictus* for Hawaiian specimens of this gecko on the basis of a number of slight variations from the characters present in *H. typus*. Perkins (1903) referred *H. leucostictus* Stejneger to the synonymy of *Lepidodactylus crepuscularis* Bavay. Brongersma (1932) made a detailed study of the geckos placed in the genus *Hemiphyllodactylus* and concluded that Stejneger's Hawaiian species, as well as the Pacific populations that had been referred to as *Lepidodactylus crepuscularis*, should be placed in the synonymy of *Hemiphyllodactylus typus*. We concur with his conclusions for this taxonomic assignment. Malcolm Smith (1935) has placed the Indian *H. aurantiacus* as a subspecies of *H. typus*, necessitating the use of a trinomial designation for the typical race.

In the Hawaiian Islands this gecko has been collected on Hawaii, Kauai and Oahu.

Gehyra mutilata (Wiegmann)
Stump-toed Gecko

Dactyloperus insulensis, Girard, 1857, Proc. Acad. Nat. Sci., Phila., p. 197 (type locality: Sandwich Islands).

Peropus mutilatus, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21, p. 796.

Gehyra mutilata, Smith, 1933, Records Indian Museum, vol. 35, pt. 1, p. 9.

The Stump-toed Gecko possesses a pronounced ability to assume coloration in harmony with that of its background. At Puuloa Point many of these lizards were observed at night on the light yellowish hardwood of the Algaroba trees from which the bark had been removed. These lizards were so pale in color as to appear to be albinos except for their large dark eyes. When resting on a dark surface, such as bark, a similarly pronounced harmony existed between the dark dorsal coloration of the lizard and that of the bark. This color varying ability made the lizards extremely difficult to see unless they moved. Specimens taken at night were on tree trunks, the outer walls of buildings and on sign boards. During the day they were found beneath rocks, under the frond bases of coconut palms and under strips of bark on Algaroba trees. From our observations this gecko seems to be equally at home in trees, on wooden structures, or on the ground in rocky areas. On Oahu it was taken with similar frequency in the lower, drier sections and in the higher, wetter parts of the island.

These geckos are essentially nocturnal in their activities and were collected in greater numbers at night than during the day. No active or exposed individuals were observed in the daytime.

The eggs are white in color and similar in shape to those of the Mourning Gecko, but are slightly larger in size. The two eggs that comprise the normal complement are usually found adhering to each other and usually flattened at the side of contact. Eggs of this species were found beneath the frond bases of coconut palms and in depressions or holes in rocks in the ground.

Stomach contents of several individuals included beetles and moths.

Henshaw (1902) reports that this gecko is included in the prey of the Hawaiian Short-eared Owl (*Asio flammeus sandwichensis*).

Much difference of opinion has existed as to the correct scientific name to use for this gecko. We follow Smith (1933) in using the generic name *Gehyra* Gray, 1834, instead of *Peropus* Wiegmann, 1835.

Stejneger (1899), having access to one of Girard's types, has shown that *Dactyloperus insulensis* Girard, which was described from the Hawaiian Islands, is identical with *Gehyra mutilata* (Wiegmann).

Definite locality records for this species in the Hawaiian Islands include Hawaii, Kauai, Kahoolawe, Maui, Molokai and Oahu.

HEMIDACTYLUS GARNOTI Duméril & Bibron
Fox Gecko

Doryura vulpecula Girard, 1857, Proc. Acad. Nat. Sci., Phila., p. 197, (type locality: "Sandwich Island").

Hemidactylus garnotii, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21, p. 792.

Lepidodactylus garnotii, Henshaw, 1902, Birds of the Hawaiian Islands, p. 80.

This is the largest and most brightly colored gecko to be found in the Hawaiian Islands. Adults may attain a total length of more than five and one-quarter inches, of which length the tail comprises slightly more than half (head-body length 65 mm and tail length 70 mm). Marked variation occurs in the number of specimens collected on the different islands and even from one locality to another on the same island.

Whether there is seasonal variation in the activities or abundance of the species we cannot say. On most islands, either the Fox or the Mourning Gecko is seen in much greater numbers than the other geckos. In the collection of 239 geckos from Oahu only 20% were Fox Geckos. Among the 42 geckos present in Fisher's Oahu material this species represents a similar percentage; in contrast, 13 of the 14 geckos collected by Fisher on Niihau were Fox Geckos. In upper Manoa valley on Oahu, Shaw found no Fox Geckos, but the Mourning Gecko was very common. In contrast, at Barber's Point, Fox and Stump-toed Geckos were equally common, but only a single Mourning Gecko was found.

The Fox Gecko appears to be more solitary in its habits than the highly gregarious Mourning Gecko, although several individuals may be found in small circumscribed areas where food and shelter are abundant, and a number of females may deposit their eggs in the same place. This species is found in more or less forested areas throughout the islands and seems to be equally abundant in the drier coastal regions and higher elevations of more abundant rainfall. It is normally most active at night when it may be found foraging for food on the trunks of trees, on the sides of buildings and on fences or walls. On Oahu a great many individuals were observed at night on the trunks of the Algaroba trees at Puuloa Point. A remarkable ability of these geckos to match the general color of their background was noted.

La Rivers (1948) reported that this species may be found sunning itself at all hours of the day and that it was seen feeding during the daytime on several occasions. The diurnal

activity observed by La Rivers appears to be unusual. It usually remains concealed during the day in deep crevices and other secluded situations. The eggs are laid under large slabs of rock, beneath loose bark on the trunks of trees, or in crevices in trees. There are typically two eggs per clutch. The eggs are white in color, nearly spherical, with a firm and brittle shell. These eggs differ from those of all other Hawaiian geckos in possessing a non-adhesive shell, thus the eggs when laid do not stick together and do not adhere to the surface on which they are laid. Snyder (1917) states that "Four or five may occasionally be found in the same place," and McGregor (1904) reported finding eight eggs in one location. These were laid by more than one female. The same workers reported that eggs of Hawaiian individuals average 10 × 11 mm in width and length. Cagle (1946-a), studying the same species on Tinian, reported that 63 eggs averaged 7 × 12 mm.

The only detailed information available on the length of incubation is provided by the studies of Cagle. On Tinian he collected 254 eggs of the Fox Gecko. The maximum length of time required for hatching was 45 days in ten instances. McGregor recorded that seven eggs collected December 27 hatched the following January 13. Snyder stated that the newly hatched young observed on the Hawaiian Islands varied considerbly in size; individuals ten hours old exhibited total lengths of 39.5 to 56 mm. In the Tinian population Cagle considered individuals with head-body lengths of 29-35 mm as hatchlings. He found that the minimum size of sexually mature females was 42 mm head-body length and 43 mm head-body length in the males.

Comparison of Snyder's data on the eggs and young of Hawaiian individuals with the observations of Cagle for Tinian geckos suggests a difference in both size of eggs and size of young at hatching. However, the difference is somewhat paradoxical in that the Hawaiian lizards appear to lay larger eggs but the young are smaller at hatching. These differences could be attributable to a difference in making measurements but this would not appear to be adequate to account for the differences noted. Furthermore, Stejneger (1899) supported Snyder's observations on the smaller size of the hatchling Hawaiian geckos. He reported a young specimen with a snout-vent length of 22 mm. We have examined three recently hatched young from Kauai that measured 23.5-24.8 mm in head-body length, with total lengths of 47-48 mm. These measurements are far below the minimum reported by Cagle, viz. 29 mm, and agree with Snyder's observations. It would be of interest to compare a large series of adults from the two island groups to determine whether or not there are statistical differences between the adults. Cagle presented interesting observations on the rate of growth of these lizards on Tinian. He calculated that sexual maturity is attained in the surprisingly short period of 30-40 days. An egg was taken at Barber's Point and hatched (or ruptured?) when it was picked up. The young lizard emerged wet and glistening from the egg material, was dried quickly, and began to shed its skin about five minutes after it had hatched.

Cagle found that the Fox Geckos on Tinian tended to remain within a small area and did not move around freely. La Rivers observed a male individual on Oahu for more than three months, during which time it remained in the vicinity of a pile of old railroad ties. Both Cagle and La Rivers found that the food of these geckos consisted mainly of insects and small invertebrates. Stomach contents of several specimens studied by us consisted of beetles, cockroaches and moths. At Puuloa Point a specimen was observed at night eating numerous small beetles that were crawling on the bark of an Algaroba tree. La Rivers tabulated 32 species of arthropods identified in the stomach contents of 27 Fox Geckos. The most frequently encountered insects were several species of beetles and various cockroaches. He went on to say that he "never saw the animal (Fox Gecko) discard a roach because of size, although some nearly adult *Periplaneta americana* (American Cockroach) seemed wider than its head." From these observations it appears that this species, like the other geckos, is an important predator of the different species of cockroaches occurring in these islands.

An adult Fox Gecko was found to be host to numerous small, dark mites that were apparently restricted to the region about the base of the tail. This lizard was placed in a jar containing a Stump-toed Gecko and the mites soon spread to the latter, where they were observed on the body in addition to the base of the tail where most appeared to settle. Several days later the Stump-toed Gecko had dropped its tail near the base, possibly because of the abundant infestation of the mites.

A number of animals prey upon this lizard. Henshaw (1902) recorded the Fox Gecko from the crop of an Hawaiian Short-eared Owl (*Asio flammeus sandwichensis*). La Rivers considered the Mongoose (*Herpestes a. auropunctatus*), the House Cat (*Felis catus*), and the Mynah (*Acridotheres tristis*) to be im-

portant predators of the Fox Gecko. This author recorded an interesting instance in which a six-inch centipede (*Scolopendra subspinipes*) killed a half-grown Fox Gecko. The centipede's poison paralyzed and killed the gecko in but a few minutes.

The types of Girard's *Doryura vulpecula* are no longer extant, but Stejneger (1899) has presented ample reasons for placing it in the synonymy of *Hemidactylus garnoti* Duméril & Bibron.

At present this gecko is known from Hawaii, Kauai, Maui, Molokai, Niihau and Oahu. It is undoubtedly present on many of the other islands as well.

Family Iguanidae — Iguanids

Anolis carolinensis porcatus Gray

Cuban Anole; "Chameleon"

Anolis carolinensis porcatus, Shaw & Breese, 1951, Herpetologica, vol. 7, p. 68.

This interesting arboreal species is the only neotropical lizard now known to be established in the Hawaiian Islands. It has the further distinction of apparently being the most recently introduced terrestrial reptile. Shaw & Breese (1951) reported the presence of the Cuban Anole in the Kaimuki district of Honolulu, the only locality from which it has been observed. In 1950 Mr. Paul Breese, the discoverer of this latest addition to the Hawaiian fauna, carefully investigated the size of the area in which it was known to occur. At that time the colony appeared to be confined to an area some 900 feet in length in a thickly settled section. However, abundant shelter and basking sites were afforded by thick ornamental shrubbery, trees, orchid houses, chicken coops, lumber piles and old fences. Breese reported that one resident stated that three of these lizards had been living in her orchid house for two or more years. The woman welcomed the new lizards because "there were white bugs in my orchids when I got them and the lizards ate them off."

That the Cuban Anole is established in a reproducing colony is clearly shown by Breese's finding eight recently hatched young on a subsequent visit to the locality. One adult female laid three eggs shortly after being collected.

At the time that this species was first reported in the Hawaiian Islands (Shaw & Breese, *loc. cit.*), it was stated that these lizards were *Anolis carolinensis porcatus*, "although somewhat atypical." This comment was called forth by the fact that, while agreeing in most details of scutellation with Cuban specimens of *porcatus*, the first three males collected in Honolulu by Breese showed an unusual amount of variation in dewlap color. Using the color terms of Ridgway (1912), the dewlaps of the males were Scarlet, Phlox Pink and Varley's Gray, respectively, with the latter having some portions a Bluish Gray-Green. Such variation is exceptional in populations of *Anolis*, where dewlap color has been employed frequently as a diagnostic character.

Since the approximate date of the introduction of this lizard on Oahu is fairly certain, it will be of interest to note carefully the fate of the colony and to follow any expansion that may take place. Because of the wide sale of *Anolis* in the pet trade, additional introductions in other parts of the islands may be expected.

Family Scincidae — Skinks

Ablepharus boutoni poecilopleurus (Wiegmann)

Snake-eyed Skink

Cryptoblepharus plagiocephalus, Girard, 1858, U. S. Expl. Exp., Herpet., p. 220

Ablepharus boutonii poecilopleurus, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21: p. 811.

Cryptoblepharus boutonii poecilopleurus, Burt & Burt, 1932, Bull. Amer. Mus. Nat. Hist., vol. LXIII, art. V: p. 512.

The Snake-eyed Skink is found on most of the larger islands of the Hawaiian group. On Oahu, it is one of the least commonly observed skinks, being apparently restricted to the drier habitats of the lowlands, but it is more frequently reported from some of the other islands. Among 57 skinks collected on Oahu, one belonged to this species. In contrast to these figures, in a collection of twenty lizards from Niihau, one-fourth were Snake-eyed Skinks. Their apparent abundance is correlated with habitat, being common in drier situations. Stejneger (1899), quoting a Mr. Knudsen, reported this lizard as exceedingly abundant on Kauai: "The skinks are as common as leaves on a tree; go along a cliff and you can see them all over it. But catch one! That is a difficult thing, for they are as quick as a flash of light and do not go far from a hole or crack in the rocks, out of which nobody can get them. I have had six smart men with me for three days promising them a dollar apiece, and all I can send is one glossy, smoothly greenish thing with tiny spots." McGregor (1904) also reported this lizard to be abundant in the lowlands on Maui, being found in the sand hills a little way back from the beach. He reported

that it is never seen near the other species of skinks known from the islands. Fisher (1948) found that the Snake-eyed Skink occurred up to an elevation of 3,200 feet in the Kau Desert on Hawaii.

This species is moderate in size compared to the other skinks of the Hawaiian Islands, attaining a length of four and a half inches (head-body length, 50 mm; tail length, 63 mm).

Because this lizard is poorly known from the larger islands, we can report little about its life history in the Hawaiian archipelago. McGregor (*supra cit.*) reported that large quantities of eggs were found deposited in damp earth. One lot consisted of more than 70 eggs in all stages of development. He stated that the shell is dull, dirty white, soft and leathery. In shape the eggs resemble those of hummingbirds, but are much rounder. They vary from 6 × 18 mm to 8 × 22 mm in size.

A considerable amount of variation occurs in the dorsal head shields of this lizard. McGregor, Stejneger and others have reported on this condition, pointing out that the variation does not appear to warrant nomenclatorial separation of the population. Also, there seems little justification for the separation of the genus *Cryptoblepharus* from *Ablepharus.*

The Snake-eyed Skink is known from Hawaii, Kauai, Maui, Molokai, Niihau and Oahu.

Emoia cyanura (Lesson)
Azure-tailed Skink

Emoia cyanura, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21: p. 807.

Emoia cyanurum var *schauinslandi* Werner, 1901, Zool. Jahrb., vol. 14, p. 380, (type locality: Molokai, Hawaiian Islands).

Dr. Walter C. Brown has revised the genus *Emoia,* but the complete results of his studies have not yet been published. He has advised us (*in litt.*) that the designation for the Hawaiian lizards will remain unchanged.

This is one of the most handsomely marked lizards of the Hawaiian Islands, with a broad light stripe on the back and a bluish-tinted tail. Some specimens exhibit a melanistic tendency, becoming quite dark in color. Such a specimen from Molokai formed the basis for Werner's form, *schauinslandi,* but these melanistic individuals appear to constitute a common variant of the species. In addition to these variations in adults, there is a considerable amount of ontogenetic variation to be noted, as pointed out by Stejneger (1899), with more contrast in color patterns to be found in young individuals. Snyder (1917) suggested that much of this variation in coloration is correlated with habitat, the darker variants coming from the moist, higher, altitudes.

The Azure-tailed Skink occurs in both the dry lowlands and at moist, wooded higher elevations above 1,000 feet. La Rivers (1948) found this lizard "an associate of the Fox gecko in this area and while not uncommon, was seldom seen because of its secretive habits." It is the largest skink occurring in the Hawaiian Islands, attaining a maximum length of more than five inches (head-body length, 43 mm, tail 83 mm).

Baker (1947)), in his report on the lizards of the New Hebrides, presented a great deal of interesting data on the life history of this lizard. At this locality in the southern hemisphere (15° 15′ S.), he found that reproduction occurred throughout the year but had a peak in November and December during the period of maximum daylight. The minimum amount of reproduction occurred in May and June, during the period of minimum daylight. Four times as many females were gravid during the maximum period as in the minimal. It would be of interest to compare this variation in rate of reproduction with that of the species in the Hawaiian Islands which are in the northern hemisphere and at a greater distance from the Equator.

La Rivers found remains of this skink in the stomach contents of the Mongoose (*Herpestes a. auropunctatus*) and the Mynah (*Acridotheres tristis*).

This lizard has been reported from Hawaii, Molokai and Oahu.

Lygosoma (Leiolopisma) metallicum (O'Shaughnessy)
Metallic Skink

Leiolopisma hawaiiensis Loveridge, 1939, Proc. Biol. Soc. Wash., vol. 52, pp. 1-2 (type locality: near Honolulu, Oahu, Hawaiian Islands).

Lygosoma (*Leiolopisma*) *metallicum.* Brongersma, 1942, Zool. Mededeelingen, vol. XXIV, p. 143.

This species appears to have reached the Hawaiian Islands sometime after the beginning of the present century, at about the time that the Moth Skink seems to have decreased in numbers. The earliest definite date of collection for the Metallic Skink in these islands is 1917. However, because this form was confused with the Moth Skink, it was not until 1939 that its presence was reported in print. In that year, Loveridge (1939) described *Leiolopisma hawaiiensis* as a new species of skink distinct from *L. noctua.* Brongersma (1942), unaware

of Loveridge's paper because of the disturbances of World War II, recorded *L. metallicum* for the first time from the Hawaiian Islands on the basis of a single male specimen.

When we began working up our material we had not yet received Brongersma's paper recording this species from the island. However, we independently reached the conclusion that our material belonged to *L. metallicum*. Mr. Arthur Loveridge of the Museum of Comparative Zoology kindly lent us some paratypic material of *L. hawaiiensis* for comparison. We concluded that the two were the same and Mr. Loveridge later confirmed this conclusion. Thus *L. hawaiiensis* Loveridge should be placed in the synonymy of *L. metallicum* (O'Shaughnessy).

This species is almost as long as the Azure-tailed Skink, attaining a total length of four and three-quarter inches (head-body length 44 mm; tail 75 mm). It derives its name from the bronze metallic sheen of the dorsal and lateral surfaces of the body.

The Metallic Skink is known in the Hawaiian Islands only from the island of Oahu, where it is locally very abundant. For example, near the mouth of Nuuanu valley large numbers of this lizard were seen sunning themselves among the leaves between the roots of a large Banyan tree. A short period of collecting here yielded 44 specimens. The lizards were not shy and would permit an approach to three or four feet before they would scurry away beneath the leaves. Many specimens were seen in the residential areas of Honolulu and near the head of Manoa valley. It occurs up to an elevation of 1,500 feet.

Unlike its congener, *L. noctua*, the Metallic Skink lays eggs. Of 15 gravid females, seven possessed four eggs per female, three had three eggs each, one had two eggs and four had only one egg each. The four females recorded as containing only one egg had all been cut open previously and may have lost additional eggs. Among fifteen adult females collected on April 21, 1944, twelve contained large developing eggs, while three contained only small eggs in the ovaries. The smallest female with eggs had a head-body length of 38 mm. In a series of 56 adults of this species, 39 are males and 17 are females. Males and females appear to have about the same average head-body length: 39.6 mm for the males and 39.8 mm for the females.

A rather high number of Metallic Skinks were observed with injured digits. Among the 69 specimens from which this information was recorded, 45% have one or more injured digits. This is a condition similar to that observed in the Moth Skink. Occasional damaged digits have been observed in other lizards in the islands, but only in these two species does this condition appear in such a high percentage of specimens. The reason for this is not known, but in the Moth Skink on Runit Island, crabs are suspected of being the causal agent.

The stomach contents of several specimens consisted of spiders, small cockroaches, larval Lepidoptera and small Hymenoptera.

Mittleman (1952) places this species in the genus *Lampropholis* Fitzinger, but he does not include the Hawaiian Islands in the distribution of the genus. Recognition of the large genus *Lygosoma* with its various subgenera, approximately as outlined by Smith (1937), seems to give a satisfactory grouping of the species and permits the nomenclatorial indication of relationship.

Unlike the other skinks known to occur in the Hawaiian Islands, the Metallic Skink is not widely distributed throughout oceanic islands of the western Pacific. It is a native of Australia, Tasmania, the Loyalty Islands and the New Hebrides Islands. It probably was brought in to the islands unintentionally with plant material or wood from Australia. Because of its great abundance on Oahu, it would seem to be only a matter of time before it is carried to other islands in the group.

Lygosoma (Leiolopisma) noctua noctua (Lesson)

Moth Skink

Lygosoma vertebrale Hallowell, 1860, Proc. Acad. Nat. Sci., Phila., p. 487 (type locality: "Sandwich Islands").

Leiolopisma noctua, Stejneger, 1899, Proc. U. S. Nat. Mus., vol. 21, p. 805.

Lygosoma (Leiolopisma) noctua noctua, Loveridge, 1948, Bull. Mus. Comp. Zool., vol. 101, no. 2, pp. 357-58.

The present status of this pretty striped lizard in the Hawaiian Islands is one of the most interesting and perplexing problems relating to the herpetofauna of the islands. Prior to the beginning of the present century, this species was the only member of the genus known to occur in the Hawaiian Islands and it was reported from several of them. As nearly as we have been able to ascertain, there are no definite records of any specimens of the Moth Skink collected in the Hawaiian Islands since 1920. One specimen in the collections of the California Academy of Sciences is without definite date of collection, and Mr. Joseph R. Slevin has advised us (*in litt.*) that this lizard,

CAS No. 47419, was collected at some time before June 26, 1920, when it was added to the Academy collection. The latest specimen that we have been able to locate with a definite date of collection was taken on Oahu in 1912.

Stejneger (1899) records five specimens collected on Hawaii and three from Hilo, where the lizard was reported to be scarce. Snyder (1917) collected but a single specimen at Honolulu. Perkins (1903) gave the following interesting note on this skink:

"I used to observe it in Honolulu, catching the insects attracted by the electric light above the doorway of a house. Here quite a little colony had established itself, but after a time a large grey rat took up its position on the ledge above the door, feeding on the moths, which it caught between its front paws, and either it devoured the lizards also or at least they disappeared."

Perkins' observation indicates that in the Hawaiian Islands *L. noctua* was a climbing form, that it was sometimes nocturnal, and that it was present, at least occasionally, in man-built habitats. Hediger (1934), writing of this species in New Britain, also reported it to be an excellent climber and found it to be a common inhabitant of native huts. On Arawe he found individuals on the kitchen table lying in wait for the ants that fed on spilled sugar.

On Runit Island at Eniwetok in the Marshall Islands we observed an unusual condition in Moth Skinks. On that island this lizard is a common ground inhabitant of the herbaceous vegetation along the beach dunes. Five of six specimens collected in about an hour's time on September 3, 1945, have two or more incomplete digits on the feet. One female has no complete digits on any foot. No definite cause of this phenomenon was readily apparent, but a possible explanation was noted. A species of small crab was very abundant in the same habitat. Often the noise and movement of a retreating crab was mistakenly interpreted to indicate the presence of a skink. It would seem highly probable that the proximity of these two animals involves some combat. The sharp claws of the crab could easily shear off the digits of any skink unwary enough to be caught by them. Fighting among the lizards might be a cause but this would seem unlikely in view of their small size.

In contrast to the Moth Skinks which were all found on the ground at Runit, four specimens of the Azure-tailed Skink, collected at the same time but under debris or beneath dead shrubs adjacent to where the Moth Skinks were collected, have no incomplete digits. In the specimens for which this information was recorded for *noctua* from the Hawaiian Islands, only one individual out of eight has any incomplete digits.

The Moth Skink is the only species of lizard known to occur on the Hawaiian Islands that brings forth its young alive. Hediger (*supra cit.*), in his studies of this form on New Britain, found only one young born per female. We have found the number of young to vary from one to two. Six of eight gravid females examined by us contained two developing embryos per female; the remaining two females had one each. This condition is not limited to females in the Hawaiian group, since we have found one or two developing embryos in females from the Marshalls, the Tuamotu and the Marquesas Islands. None of four females collected in Hawaii in July possessed developing embryos, whereas all of seven females taken in September have embryos.

This species appears to be entirely insectivorous in its food habits.

The largest specimen with a complete tail that we have measured from the Hawaiian Islands was nearly four inches in total length (40 mm head-body length, 58 mm tail length). Even this measurement is below the length recorded for specimens from other islands in the Pacific, where head-body lengths of more than 50 mm and tail lengths of more than 68 mm have been recorded. Females appear to attain a slightly greater length than males.

Hallowell's (1860) *Lygosoma vertebrale* was described on the basis of a type specimen from the "Sandwich Islands." This type is no longer extant, but the description leaves little doubt that his specimen is referable to this species.

Mittleman (1952) places this species in the genus *Lipinia* Gray, but he does not list the Hawaiian Islands in the distribution of the genus. As stated under the discussion of the Metallic Skink, we believe the classification and nomenclature of Smith (1937) for the large genus *Lygosoma* and its several subgenera has more to recommend it than the classification proposed by Mittleman.

The Moth Skink has been reported from Hawaii, Kauai, Maui and Oahu.

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